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ENCYCLOPEDIA OF KNOWLEDGE

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Sewall, Samuel [soo'-ul] Samuel Sewall, b. Bishopstoke, England, Mar. 28, 1652, d. Jan. 1, 1730, a judge in colonial Massachusetts, was one of the presiding commissioners at the 1692 SALEM WITCH TRIALS. In 1697, Sewall publicly confessed his error in concurring with the death sentences imposed. Chief justice of the superior court (1718–28), he wrote an early antislavery tract, *The Selling of Joseph* (1700).

Seward, William H. [soo'-urd] William Henry Seward, b. Florida, N.Y., May 16, 1801, d. Oct. 10, 1872, was a Republican party leader and U.S. secretary of state (1861–69). After practicing law he entered New York politics and became a state senator (1830–34), the first Whig governor of New York (1838–42), and a U.S. senator (1849–61).

Although he did not think blacks equal to whites, Seward was an outspoken opponent of slavery. In 1850 he advocated barring slavery from the territories by appealing to a "higher law than the Constitution." That year he also described sectional controversy as an "irrepressible conflict," thereby earning an unmerited reputation for radicalism.

Seward was the front-runner for the 1860 Republican presidential nomination but failed to attain it. Appointed secretary of state by his successful rival, President Abraham Lincoln, Seward succeeded in maintaining good relations with European nations during the Civil War and in preventing them from extending recognition to the Confederacy. After settling the TRENT AFFAIR amicably by releasing two Confederate agents who had been removed from a British ship, he convinced England that British recognition of the South would mean war. He waited until after the Confederate surrender before pressing strongly for French withdrawal from Mexico.

Lincoln came to trust Seward's advice on domestic questions, most notably in delaying the announcement of the Emancipation Proclamation until after the Union victory at Antietam in 1862. John Wilkes Booth included Seward as a target in the assassination plot that succeeded in killing Lincoln; although severely wounded, Seward survived. Continuing as secretary of state under Andrew Johnson, he backed the president against Radical Republican attacks. An expansionist, Seward purchased (1867) Alaska for the United States and favored the acquisition of the Danish West Indies (the Virgin Islands) and Hawaii.

William Seward, secretary of state under Abraham Lincoln, advised the president during the crisis of secession and the outbreak of the Civil War. Seward retained his cabinet position under Andrew Johnson and in 1867 purchased the Alaska territory, an act ridiculed as "Seward's Folly."

Sewell, Anna see BLACK BEAUTY

sewellel [suh-wel'-ul] The sewellel, *Aplodontia rufa*, more commonly called the mountain beaver, is the only living member of the family Aplondontiidae in the order Rodentia. It has a thickset body, short legs and ears, and a stubby tail. Its short, dense fur is a uniform reddish to blackish brown with a white spot beneath each ear. A large mountain beaver stands about 45 cm (18 in) long, 13 cm (5 in) high at the shoulder and weighs 1.8 kg (4 lb). Mountain beavers live in small colonies in burrows commonly dug near water and feed on green plants and bark. They are found only in a narrow range from southern British Columbia to San Francisco Bay.

sewerage A sewerage system collects rainwater and waterborne wastes through drains, pipes, and sewers; treats the wastes to remove solids and disease-causing bacteria; and discharges the treated water into a natural watercourse or returns it to the public water supply.

Urban sewerage systems in the Western world remained much the same until well into the 19th century. They were designed primarily to collect overflow rainwater; open drains were standard; no provision was made for collecting domestic wastes, which entered the system haphazardly; and all wastewater was discharged into a local waterway. Such systems were adequate so long as populations remained relatively small. When populations grew, however, and local waterways could no longer cleanse themselves of bacterial contaminants, it became necessary to treat wastewater before it was discharged back into a river or lake.

Sewerage Systems. Some city systems use one sewer network for domestic and industrial wastewaters, and another for rainwater, which is emptied without treatment into a local waterway. This separation ensures that no foul sewage is ever discharged into a waterway without treatment. Combined systems use one network for both rainwater and wastewater.

The most practicable system for a given area depends on the topography, the climate, and the type and extent of industries in the area. Gravity flow in sewers is desirable, but this might entail laying pipes at too great a depth for safe and efficient maintenance. Carefully sited pumping stations with emergency overflows can provide an alternative.

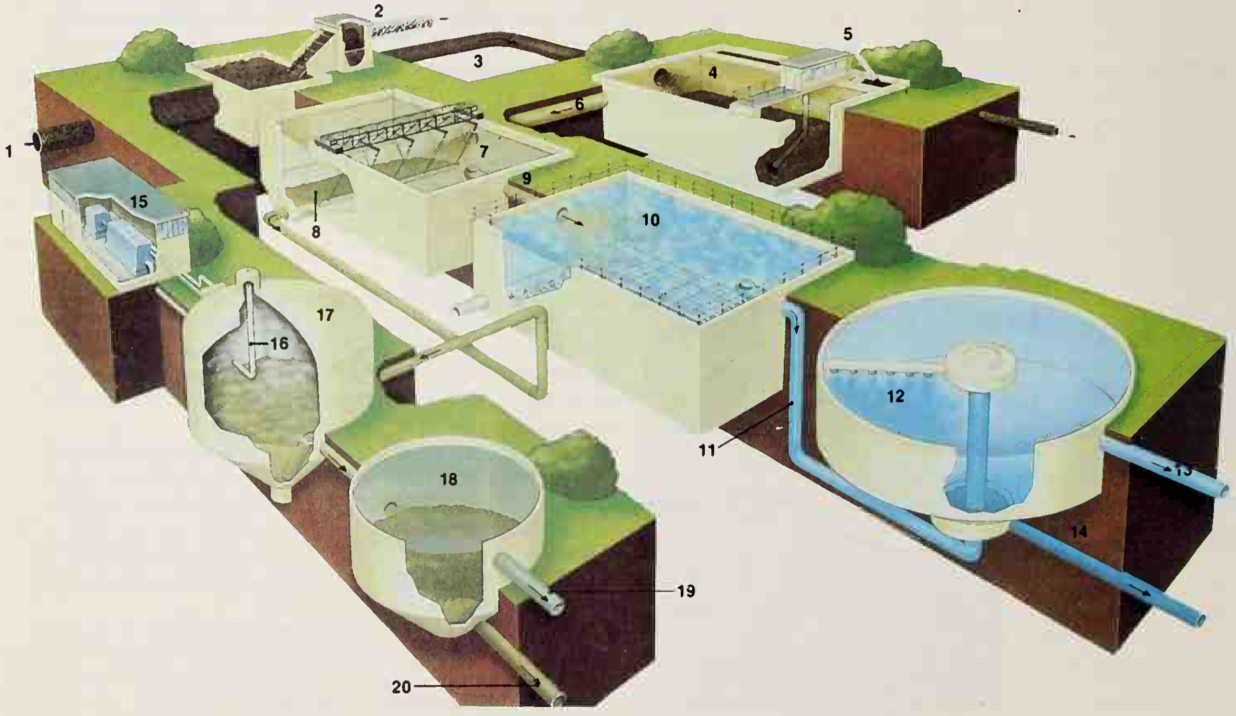
The normal flow through a sewerage system is the dry weather flow (DWF), an average flow over a 24-hour period. Flow is at a minimum at about 2:00 AM and has two maxima, usually around 7:00 AM and 5:00 PM, depending on climate and social habits. In combined systems, storm-overflow weirs are set to operate at six times the DWF on the assumption that sewage diluted with five volumes of rainwater could be discharged into a stream without risk of serious pollution. If, however, a storm coincides with one of the daily maxima in sewage flow, the mixture overflowing as stormwater is much stronger than the intended 5-to-1 ratio and is potentially dangerous as a pollutant. Modern practice provides for automatic screening of storm-overflow sewerage and also for storage of the first flushes that are subsequently fed back into the system for full treatment if such facilities are available. In areas where sudden rainstorms are infrequent, the first flush of runoff can be stronger than sewage and requires correspondingly extensive treatment. In such areas even completely separate systems do not permit the unrestricted discharge of stormwaters. To prevent deposition of solids in a sewer, with consequent slime growth and risk of blockage, the forward velocity should be 0.75 m/s (2.5 ft/s)—this rate to be attained at least once per day.

New Systems. Planning a sewerage system adequate to serve the existing needs and future development of an area is a complex matter. Natural drainage basins may be used to supply pumping stations that convey sewage to a treatment plant and disposal point. Alternatively, if the drainage basins are of sufficient size, they may each contain a treatment plant, with the effluent gravitating or being pumped to a disposal point.

In warmer climates, sewage is liable to putrefy in long lengths of sewer even though apparently adequate ventilation systems are installed. As a result, bacterial action produces methane, carbon dioxide, and hydrogen sulfide, which could create hazards for sewer-maintenance personnel and deterioration of concrete and brick sewers.

When completely new contiguous industrial and residential areas are developed, the best way to handle their sewage problems is to provide separate sewerage and treatment systems for the two areas. Agricultural industries such as food manufacture produce wastewaters similar in character to kitchen waste, but because the quantity and concentration are so great, they may best be treated in a separate specialized plant before they leave the factory. Other types of industrial wastewaters may contain toxic chemicals and require specialized methods

In a typical secondary sewage treatment plant, after raw sewage (1) *enters the plant, coarse screens* (2) *remove wood, rags, and other solid trash. The screened sewage* (3) *is pumped to grit-settling tanks* (4), *where grit and sand settle to the bottom and are removed* (5). *Grit-free sewage* (6) *flows into primary sedimentation tanks* (7), *where about one-half of the suspended solids settle out to form sludge* (8), *which is pumped to digestion tanks. The remaining sewage* (9) *is pumped to the aerator* (10) *to be mixed with bacteria-rich (activated) sludge. As air is injected into the aerator, aerobic bacteria oxidize organic matter in the sewage. Aerated sewage* (11) *passes into a secondary sedimentation tank* (12), *where the activated sludge settles out. The remaining effluent* (13) *is filtered, treated with chlorine, and released into a lake or river; the activated sludge* (14) *is recycled into the aerator. In the power house* (15), *methane gas from a collector* (16) *is burned to heat the primary digestion tanks* (17), *where anaerobic microorganisms digest sludge from the primary sedimentation tanks. Digestion, completed in secondary tanks* (18), *produces concentrated sludge* (19), *which may be removed and used as fertilizer, and water* (20) *to be discharged.*



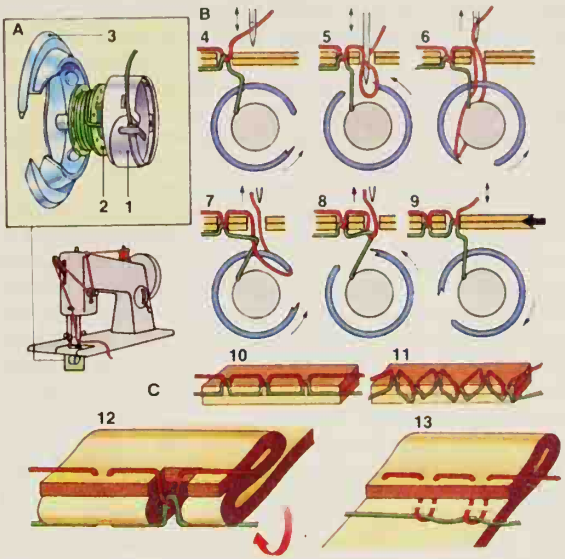
for their purification; they may also interfere with or inhibit the normal biological methods used to treat city sewage.

Sewage Treatment. The purpose of a sewage purification plant is to render the sewage stable and suitable for discharge into a natural water without adversely affecting the chemistry or biology of the water. Until the last quarter of the 19th century little treatment was given to sewage, and it was generally disposed of by dilution or by irrigation. Increasing use of piped water and the expansion of industry have made such crude methods impracticable, and other methods have been developed. Most methods are based on natural biological processes of oxidation by microorganisms, and they include attempts to accelerate these processes by various means. The object is to ensure a sufficient supply of air (or oxygen) to stimulate the action of the microorganisms, causing the processes of biological oxidation to occur as rapidly as possible. During the process, as the microorganisms grow and die, they leave behind a residue known as secondary sludge, which also must be oxidized. The oxidation may occur in shallow artificial ponds where the air is introduced mechanically; in suitable climates, sunshine and algae combine to effect purification. Deep ponds may be aerated mechanically or by compressed air introduced through diffusers. Purification works have traditionally been constructed in massive concrete tanks. Ready-made small plants with sheet-steel tanks that have easily assembled internal parts have recently been introduced, as have plastic liners for ponds. A trend has also been developing toward replacing large treatment plants with many small, simple plants that can be operated automatically and do not require complicated sewerage systems.

Among the oldest methods, still widely used, is the biological, or trickling, filter. It originated as a pile of limestone chips over which the sewage was allowed to flow in a thin stream; the microorganisms form a biofilm on the surface of the stones and feed off the content of the sewage. The method is frequently used for the purification of industrial effluents from organic processes; it is flexible and robust. After biopurification a final process is frequently applied to sewage effluents before they are discharged into recreational waters. This process may comprise filtration through sand or by microstrainer or percolation through a grass plot that acts as a self-cleaning filter.

Sewerage treatment plants are classified according to how extensively they treat wastewater. In a primary treatment plant, only those suspended solids which settle out in a sedimentation tank are removed, and the water is then discharged. A secondary treatment plant adds biological treatment to simple sedimentation. Tertiary treatment is necessary where the wastewater will be directly reused. It removes dissolved solids (synthetic chemicals, heavy metals) with advanced removal techniques such as electrodialysis, reverse osmosis, ion exchange, and distillation.

sewing see EMBROIDERY; NEEDLEWORK



The modern sewing machine is driven by an electric motor. The movements of the needle arm and the bobbin (A) *are synchronized and driven by the motor. A stitch is formed with the thread from both the needle and the bobbin. The bobbin case* (1) *surrounds the bobbin* (2) *in a housing* (3) *that rotates beneath the sewing table.* (B) *First the needle descends* (4) *through the cloth, and as the needle rises it forms a loop* (5). *The loop passes around the bobbin* (6) *and surrounds the bobbin thread* (7). *As the bobbin rotates, the loop slips off* (8), *and the stitch is tightened around the cloth by the thread take-up lever. When the needle is above the cloth, the fabric feed advances the cloth, and another stitch begins* (9). (C) *The lock stitch* (10) *and the zigzag stitch* (11) *are standard stitches. The hemming stitch is also shown* (12, 13).

sewing machine A mechanical device for stitching cloth and other materials, the sewing machine was not so much invented as developed over the course of a century of accelerated technological progress. One of the first machines to receive a patent was designed by a French tailor named Barthélemy Thimonnier in 1830. By 1841, 80 of his machines were being used to sew uniforms for the French army.

A half-century of experimentation finally bore fruit through the inventions of Elias Howe and Isaac M. Singer. Howe patented his machine in 1846. When other inventors began building machines based on his designs and infringing on his patent, Howe sued and was granted full rights and a royalty of $25 on each machine.

Singer produced (1850) the first truly practical sewing machine. It was made with an overhanging arm, a table to support the cloth, a presser foot to hold the material down, a feed wheel to feed the fabric under the needle, and—the real breakthrough—a foot treadle instead of a hand crank, leaving both hands free to maneuver the cloth as it moved under the needle. By the 1850s, Singer sewing machines were being sold in showrooms for $75. Despite the price thousands of machines were sold, thanks in part to another of Singer's innovations—the installment plan.

During the 1930s the foot treadle was replaced by an electric motor. In the late 1940s the new technique of zigzag stitching, with the needle moving from side to side as well as up and down, allowed even inexperienced sewers to make buttonholes, sew on buttons, blindstitch, finish seam edges, embroider, appliqué, and monogram. The basic zigzag machine was improved with cams, discs, and special settings that made possible a variety of stitches. As knit fabrics became popular, a stretch stitch was invented that gave the seam as much stretch as the fabric, eliminating popped seams.

The newest sewing machines are electronic, activated by a microelement that controls all the stitching systems. Newly developed machines have brought sewing to the handicapped by incorporating braille symbols and instruction cassettes, special finger guides and guards, and controls that can be operated by knee, hand, or elbow. Specialized industrial machines for the most part are designed to perform a single function, and computer-controlled machines can be programmed to produce a complete unit of work without a machine operator.

sex Sex, in the most basic biological definition, is any natural process by which a new cell is produced through a recombination of genes from two genetically different parent cells. How sex arose is lost in the geological record. Asexual organisms lacking cell nuclei also take part in a process in which nucleic-acid fragments are transferred (see CONJUGATION, biology), but biologists do not regard this as ancestral to the sexual process of cell division observed in more advanced life-forms. On the other hand, exclusively sexual reproduction occurs only in birds and mammals. In other life-forms it may occur along with asexuality (including parthenogenesis) and self-fertilization (see REPRODUCTION).

To some biologists the persistence of sex in evolutionary history is hard to understand, because in many ways it is less efficient than other processes. The exchange of genetic material is commonly viewed as advantageous because some of the new organisms will be more successfully adapted to the environment than were the parent forms; in addition, the exchange can also be viewed as lessening the effects of harmful mutations through repair of damaged genes. Other theorists, however, point out that these processes are advantageous only in terms of species, whereas natural selection, viewed nonpurposively, should work best at the individual level. Some scientists even propose that sex be seen as a parasitic mechanism for nucleic-acid transference that first appeared in viruses and to which other forms of life have had to adapt. Although this is an extreme view, the why of sex remains an interesting controversy in biology.

sex change see SEX REASSIGNMENT

sex education Sex education is viewed as a formal instructional program to provide children and young adults with an objective understanding of sex as a biological, psychological, and social life force. A comprehensive curriculum, developed for sequential age levels, would include discussion of the maturation and reproductive processes and extend to such related considerations as obligations to the self and others; protection from sexually related disease, exploitation, and injury; and awareness of the maturity required for full expression of sex in love relationships.

Supporters of formal sex education consider that sex in modern society is too complex a phenomenon for instruction to be left to the varying influences of parental attitudes and haphazard environmental exposure. They maintain that sex education is a preventive measure against venereal diseases or pregnancy, as well as a cultural force for the development of mature psychosexual relationships in adult life. Opponents hold that sex education is the exclusive right of parents and that encroachments upon this right will erode the traditional family and religious restraints on sexual activity.

The national movement for sex education started in the 1940s but remained sporadic and limited to local constituencies until the late 1960s, when government and educational organizations developed sex-education programs. A few states have adopted mandatory courses.

sex hormones Sex hormones, which are essential for the normal SEXUAL DEVELOPMENT and function of the REPRODUCTIVE SYSTEM, are produced mainly by the male and female sex organs, otherwise known as gonads. Biochemically, these hormones are steroids; they are known as androgens, estrogens, and progesterone. The hypothalamus and pituitary regulate the secretion of these sex hormones at puberty and during the reproductive phase of adulthood. Also, the adrenal cortex of both sexes produces small quantities of androgens and progesterone.

Sex hormones are required in mammals to maintain sex drive and potency. Most females can mate only during estrus, or heat, at certain times of the year, which coincides with ovulation and thus maximizes the potential for procreation. A human female, however, can enjoy a normal sex life at any stage of her cycle as well as after removal of her ovaries or following menopause. Unlike in other mammals, ovulation in human females is not marked by a change in behavior, pheromone release, or other sign obvious to males.

Hormonal Control in Females

Estrogen. Estrogens are secreted by a mature ovarian follicle, which surrounds the ovum, or egg. During puberty, follicles are stimulated by pituitary hormones that are transported by means of the bloodstream. At this time, the fallopian tubes, uterus, and vagina increase in size, and menstruation begins. During puberty females also experience a spurt of growth: their height increases and the pelvis broadens. Breasts develop; hips become rounded and the skin becomes softer as a result of fat deposition just underneath the skin. Also, pubic and underarm hair begins to grow. All these changes are regulated by estrogens and androgens.

Progesterone. In nonpregnant women, progesterone is secreted by the corpus luteum, which develops from a ruptured follicle after ovulation to prepare the uterine lining for possible implantation of a fertilized egg. In pregnant women, progesterone is secreted by the placenta.

Brain Regulation of Sex Hormones. The secretion of sex hormones by female gonads is regulated mainly by luteinizing hormone (LH), which is secreted by the anterior pituitary. LH, in turn, is controlled by the luteinizing hormone releasing factor (LRF), which is produced in the hypothalamus.

Follicle-stimulating hormone (FSH), which is also released from the anterior pituitary, enhances the actions of LH on ovulation and sex-hormone production. FSH is primarily responsible for the development of a follicle before ovulation.

Reproductive Cycle. Hormonal levels rise and fall on a monthly basis during a female's reproductive years (see MENSTRUATION). During the menstrual cycle, a growing follicle produces large quantities of estrogen, which stimulates increased secretions from the linings of the vagina, the uterus, and the fallopian tubes. Estrogen levels peak toward mid-cycle, stimulating a surge of LH and FSH just prior to ovulation. After ovulation, high levels of progesterone, secreted by the corpus luteum, prepare the uterus for implantation of a fertilized egg and the development of a fetus. During PREGNANCY, large amounts of estrogen and progesterone are produced by the placenta in order to maintain the proper uterine environment for a developing fetus. Also, these two hormones cause breasts to swell in preparation for lactation.

Hypogonadism and Menopause. Hypogonadism in females, a condition in which ovaries fail to develop, reduces the feminizing influences on the body and causes greater height increase than in normal women. At MENOPAUSE, or the cessation of ovarian function, progesterone and estrogen levels fall, causing atrophy of the gonads and breasts and also increasing the woman's risk for heart disease and OSTEOPOROSIS. Menopausal women often undergo hormone-replacement therapy to reduce their risks from these diseases, as well as to prevent common discomforts of menopause.

Hormonal Regulation in Males

Several male hormones, or androgens, are secreted primarily by the interstitial cells of the testes. The production of testosterone, the principal androgen, is stimulated by interstitial cell-stimulating hormone (ICSH), which is identical to LH, released by the anterior pituitary under the influence of LRF.

Testosterone. Testosterone plays an essential role in male development and function during three stages of life. In the first trimester of pregnancy, this androgen produced by the fetal testes is responsible for the differentiation of the male reproductive tract. At puberty, testosterone stimulates an overall body growth, including increased muscle mass; growth of the vocal cords, which results in a deeper voice; and growth of facial, axillary, pubic, and general body hair. Frequently, it stimulates excess secretion from sebaceous glands in the skin, causing acne. At this time, the external genitals attain their full adult proportions, semen production commences, and the capacity for erection and ejaculation is stimulated. Finally, in adulthood, testosterone is continually secreted to maintain normal reproductive function, sperm production, and male sexual behavior. Testosterone levels may decline in males after about the age of 60.

Hypogonadism and Castration. In male children afflicted with hypogonadism, caused by undeveloped testes, normal masculine characteristics and sexual function fail to develop properly. Castration or failure of testicular androgen production in men after puberty only slightly affects the size of the penis, but the capacity for erection declines or disappears, ejaculation is impossible, and, because of the lack of androgen to influence the brain, sexual desire fades.

sex reassignment Sex reassignment refers to the surgical changing of a transsexual human's biological sex. A transsexual is a person, male or female, who perceives his or her gender identity as incongruous with the anatomical reality and actively seeks to resolve the conflict through sex-reassignment surgery. The term *transsexual* is used to refer to both pre- and postoperative men and women, although once surgery is completed the new description of *male* or *female* is preferred.

Sex reassignment for transsexual humans requires various social, hormonal, legal, and surgical procedures. Social reassignment involves living and working as a member of the sex opposite from that which a person was born. In some cases, social reassignment suffices. In other cases, hormonal reassignment is required, in which hormonal therapy partially suppresses the existing phenotypic sex characteristics of the body and allows the development and maintenance of characteristics of the opposite sex. For male-to-female transsexuals, electrolysis of beard and body hair is necessary because estrogen does not stop hair growth. Also, estrogen does not elevate the pitch of the voice, although androgen lowers voice pitch in female-to-male transsexuals. In the United States, a legal change of sex involves chiefly a change in the birth certificate, but in Europe, legal reassignment is a more complex procedure.

Surgery

In the female-to-male transsexual, mastectomy might, for cosmetic and employment reasons, antedate surgery of the reproductive organs, which involves hysterectomy (removal of the uterus) and oophorectomy (removal of the ovaries). For some female-to-male patients, subsequent phalloplasty (plastic surgery to attach a penis) is important for their body image and self-concept. Phalloplasty is sought by these transsexuals despite the possible imperfection of the organ for urination and its guaranteed imperfection for copulation.

The surgical technique for phalloplasty involves an attempt to create a tubular structure in a progressive series of operations in which the skin is peeled, rolled, and subsequently transplanted from the lower abdomen or inner thigh. This rolled skin is then attached in the position of a penis. The clitoris is left intact, embedded at the base of the penis, to preserve erotic sensation.

In male-to-female surgery, the penis and testicles are removed and a vulva and vagina are constructed by using the skin from the penis to line a vaginal cavity, which has been surgically opened. If the penile skin is not adequate, an augmenting skin graft is used. Some male-to-female transsexuals also undergo surgery to enlarge the breasts and seek other forms of feminizing cosmetic surgery, such as rhinoplasty (nose surgery) and hip augmentation. For those patients whose vocal cords have not become permanently habituated toward a feminine register, surgery can be used to shorten the vocal cords in order to elevate the pitch of the voice.

Transsexualism

On the basis of endocrine techniques now available, it is not possible to demonstrate a difference in steroidal sex hormones from the gonads in transsexual patients and those in normal control groups. Transsexual patients possibly are atypical, however, with respect to the way in which the brain's hypothalamic-releasing hormones respond to and interact with pituitary and gonadal hormones. If such evidence proves correct, the transsexual condition most likely originates during prenatal or early infantile periods.

The developmental biographies of transsexuals vary. One type is that of effeminate males and, conversely, virilistic females. Such people have a history of active erotic imagery, if not experience, with same-sex partners from a very early age. A second type is that of a person who, even if he or she manifested no cross-gender signs in childhood and adolescence, was always secretly obsessed with being sex-reassigned; at puberty this person is erotically inert. A third type is that of a person who has a history of transvestism, manifesting two names, two wardrobes, and two personalities until middle life when, under the pressure of a major life crisis, full-blown transsexualism emerges.

Transsexualism is a method of rehabilitation in selected, relatively rare cases of severe displeasure with a person's natal gender. One way to evaluate the probable success of sex reassignment is to spend two years living, working, and becoming rehabilitated as a member of the other sex. Hormonal reassignment can be reversed, but surgical reassignment cannot; therefore, if all psychological and social consequences of sex reassignment are negotiated far ahead of surgery, the chances of error are virtually eliminated.

sex roles The term *sex roles* refers to behavior and characteristics that are considered both typical (sex-role stereotypes) and desirable (sex-role norms) for males and females in a particular culture. They are socially defined components of gender, although they have some basis in biology. Biological sex is defined by the physical characteristics that differentiate one sex from the other. Sex-role identity refers to the way in which a person internalizes his or her socially defined sex role. Gender identity is the degree to which a person feels comfortable with his or her biological sex.

Sex-Role Influences. From the earliest moments in life, a person's gender influences and is influenced by society's understanding of what it is to be female or male. A complex interaction of biological factors, such as chromosomes, hormones, and genitals, combines with a variety of social factors and personal history to form an individual's sex-role identity (see SEXUAL DEVELOPMENT).

Because sex roles are learned through interactions with other people, especially parents, teachers, and peers, as well as through portrayals of people in the media, they vary from individual to individual and from society to society. Even within a given culture, individuals can vary in the degree to which they adopt sex roles. Some people may not restrict their behavior to one sex-role type but may adopt behaviors socially associated with both female and male sex roles. Such people are said to have an androgynous sex-role identity.

Sex is one of the major components of a person's definition of him- or herself and others. Children learn very early to label themselves "girl" or "boy." In cultures that emphasize sex-role identity, these self-labels become an important part of a person's concept of self. There is some evidence that children actively seek out models and information about sex roles, apparently to maintain a stable self-identity as girl or boy.

Because sex roles carry with them prescriptions for behavior with others, individuals need to know the sex of the person or persons with whom they are interacting—if for no other reason than to feel comfortable. Thus people use such indicators as hairstyle, dress, and facial appearance, nonverbal cues such as demeanor and mannerisms, and language styles to determine another person's sex.

Biological Differences. The degree to which biology controls behavior reflects, in part, choices a society makes. A society may choose either to emphasize or to compensate for biological predispositions. For example, if females have a biological predisposition to learn nurturant behaviors more readily than males, a society could make an extra effort to foster nurturant behaviors in males. On the other hand, it could exaggerate the difference by putting more emphasis on nurturance in females.

Historical and Theoretical Overviews. Some division of labor between the sexes is found in nearly every culture, but there is variability across societies in what the division of labor is and how rigid it is.

The nature of a society and its economy are related to the different positions of women and men. In early hunting-and-gathering societies, both sexes contributed to the food supply. In many such societies the position of the sexes was relatively egalitarian. Later agrarian societies were accompanied by the development of the concept of private property. Under these conditions the position of women declined, and their lives became more restricted. The division between the domestic and public spheres became sharper in capitalist industrial societies, with women relegated to the former and men to the latter. In Western industrial societies increased demand for white-collar and service-sector employees has resulted in an increase in women's participation in the public sphere during the 20th century. Sociological and anthropological studies have suggested that a concomitant increase in men's involvement in the domestic sphere would result in greater flexibility of sex roles and greater equality between the sexes.

See **also:** WOMEN IN SOCIETY.

sex therapy Sex therapy involves the treatment of sexual disorders, variances, and dysfunctions. In particular, sex-therapy programs are directed toward the solution of such sexual problems as impotence, premature ejaculation, retarded ejaculation, painful coitus, sexual unresponsiveness, and orgasmic dysfunction. A common assumption underlying many modern sex-therapy programs is that sexual problems are often learned and hence can be corrected through relatively brief intervention measures. Intensive psychotherapy and medical treatment may be given when emotional disturbances or physical disorders, or both, compound sexual difficulties.

Sex-therapy programs generally attempt to help people by providing appropriate sex information; by alleviating anxieties and fears about sexual performance; and by facilitating verbal, emotional, and sexual communication between sex partners. Sex instruction, followed by private home assignments in which a couple practices newly learned, healthier ways of interacting, is an integral part of many sex-therapy programs.

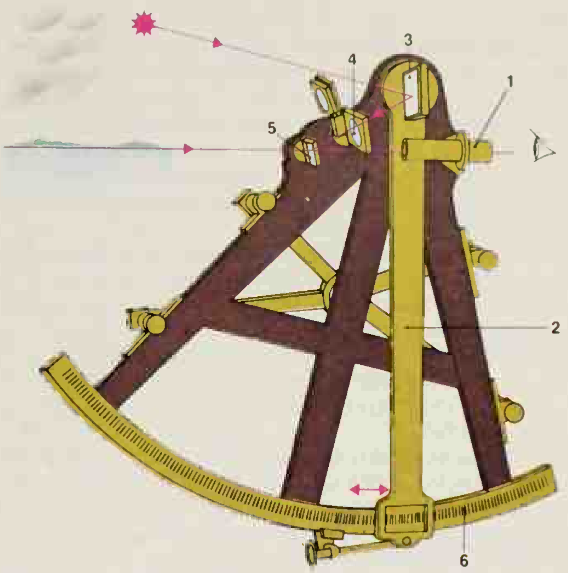
Both partners in the couple are often included in sex-therapy programs. Sometimes, however, it is reasonable for a single person or only one member of a couple to be counseled, depending on the nature of the sexual problem. Group-therapy techniques, including either groups of individuals or couples, are often used in sex-therapy programs.

See **also:** MASTERS AND JOHNSON REPORTS.

sexism Sexism is defined as discrimination or prejudice based on gender. The word is usually used, however, to connote an ideology of male superiority derived from a set of assumptions regarding the nature of woman, namely, that she is inherently inferior intellectually, psychologically, and physically to man. The sexist view, shared by both men and women, has historically shaped institutions of world society. It has been perpetuated through the acculturation of generations of children with resultant differences between the sexes. Sexism was not effectively challenged until the 20th century, with the growth of the militant women's-rights movements. Sexism, however, remains a major influence on both conscious and unconscious assumptions in mass culture.

See **also:** DISCRIMINATION; FEMINISM; SEX ROLES; SUFFRAGE, WOMEN'S; WOMEN IN SOCIETY.

sextant A sextant is an optical instrument used in navigation to measure the angles of celestial bodies above the horizon from the observer's position. In use since the mid-18th century, the sextant is so named because the early instrument had a calibrated arc (the limb) that is one-sixth of a circle (60 degrees). Early marine sextants were hand held and leveled on the horizon. In modern sextants, which use arcs of greater or lesser size than the original type, the light ray from the celestial body is reflected in two mirrors (in series), one of which is adjustable and the other of which is half-silvered. By rotating one mirror and its attached index bar, the image of the body is brought down to the horizon. The rotation measures the altitude on the limb. Air sextants, used in aircraft navigation, use a bubble encased in fluid, a pendulum, or a gyroscope to create an artificial horizon.



To measure the angular distance between the Sun and the horizon, the sextant is held so that the horizon is visible through the telescope (1). *The index, or movable arm* (2), *and the attached mirror* (3) *are rotated so that the image of the Sun is reflected through the darkened glass* (4) *into the half-silvered mirror* (5) *until the Sun is aligned with the horizon. The angle is read on the limb, or calibrated arc* (6).

Sexton, Anne [seks'-tuhn] An American poet of the confessional school associated with Robert Lowell, Anne Harvey Sexton, b. Newton, Mass., Nov. 9, 1928, d. Oct. 4, 1974, won a Pulitzer Prize for her collection *Live or Die* (1966), which contains some of her finest poems. Her first volume, *To Bedlam and Part Way Back* (1960), was the unsentimental account of a mental breakdown, and *All My Pretty Ones* (1962) established her as a powerful poet of anguish. Influenced by Rilke, Rimbaud, Kafka, and her friend Sylvia Plath, Sexton used freer verse forms and more startling imagery in her later poems. *The Awful Rowing toward God* (1975) was published after her suicide.

sexual development Human sexual development involves certain basic biological processes that begin with conception and continue on into maturity. Social influences are also involved in sexual development. Such influences may vary from culture to culture according to value systems, stereotypes of masculinity and femininity, conventions and taboos of sexual behavior, and child-rearing philosophies.

Psychological attitudes and emotions also affect sexual development, and these can vary from individual to individual. Cultures differ in the subtle differences in sexual attitudes conveyed to children by their families, and no two families are ever quite identical. Emotions arise in response to family experiences as well as to other social experiences. These emotions can influence sexual development powerfully.

Because biological, social, and psychological influences all continue to change throughout the life of a human being, sexual development is a process that never ends.

Prenatal Sexual Development

Sexual development begins at conception (see DEVELOPMENT, HUMAN). The female ovum contributes an X chromosome to the embryo. If the male sperm contributes another X chromosome, the embryo will develop ovaries and become a female. If the sperm instead contributes a Y chromosome, the embryo will begin to develop androgen-producing testes at 6 weeks and become a male. (Androgen is a male SEX HORMONE.) In 1990 geneticists found strong evidence that a single gene on the Y chromosome determines this outcome. Thus an abnormal Y chromosome that lacks this specific gene can result in a fetus with XY chromosomes that even so develops as a female. Alternatively, an abnormal X chromosome that contains the gene can result in a fetus with XX chromosomes that nevertheless develops as a male.

Under the influence of androgens, male sex organs are formed by 14 weeks. Additionally, the androgens organize parts of the developing male brain so that the individual will exhibit behavior that is statistically more typical of males than females. After puberty the male sex hormones will be produced steadily and, among other effects, play a role in male libido.

In female fetuses no androgens are produced, and this permits female genitals and internal organs to form during the same early period. Androgen absence also leads to organization of parts of the developing female brain so that behavior patterns predominate that are statistically more typical of females than males. Female sex hormones will be produced in a cyclic pattern (which accounts for the menstrual cycle), and play a role in sexual arousal. Behavioral scientists disagree about the nature and extent of innate sex-specific behavior and attitudes. Pervasive cross-cultural similarities and other human and animal research suggest that some sex-specific characteristics are innate but that they are not mutually exclusive. All behaviors and attitudes can normally exist in either sex, but some patterns are statistically more common in one or the other.

Infancy

Newborn infants of either sex are much more alike than different but do show some sex-specific differences. Statistically, boys are larger at birth, can raise their heads higher than girls, are more irritable and difficult to calm, and within a few months show more anger and aggression. Older male infants are less fearful and more active in strange situations and cling less to their mothers. These attributes correlate with the greater physical aggressiveness and use of energy in males of all ages cross-culturally and also in primates and other mammals. Girls are quieter and more sensitive to touch, smile earlier and more often (even in sleep), are more responsive to social stimuli, and talk more and earlier than boys. They are less exploratory and more fearful in strange situations.

It is difficult to separate innate differences from learned responses to the different ways parents act toward boys and girls beginning at birth. Mothers are more attentive to the fussiness of boys and play more vigorously with them, whereas they elicit more vocalizing and smiling from girls. With older infants mothers tolerate more aggression and independence in boys. These same differences occur in widely divergent cultures and other species, suggesting that parental behavior does not spring simply from preconceptions about masculinity or femininity but responds to and fosters innate sex-specific temperaments and behaviors.

From birth, parents and society begin to teach an infant that it is male or female and, as it grows older, what the different expectations are of each sex. By 2 years of age, children normally have an unchangeable inner sense of being male or female. This early learning is also the beginning of the wide cultural and individual variations in the accepted norms of maleness and femaleness.

Early Childhood

With good, physically affectionate parenting, infants learn that their own and others' bodies are good and that physical closeness may be trusted. Next, during the separation and individuation of toddlerhood, children may learn that they own their bodies, which includes the right to all body parts and sensations. Toddlers discover genital sexual differences and the pleasure of touching their genitals. The attitudes of parents toward a child's sexual curiosities and genital fondling determine whether the child accepts his or her genitals and sensations as good and prideful or bad and shameful. From this time on, each sex must learn what it means, personally and socially, to be male or female.

Initially, all infants identify with the mother, but during toddlerhood they begin to identify appropriately with the same-sex parent. It is also normal for toddlers to express wishes to be like the opposite-sex parent, although persistent cross-sex identification is abnormal. Toddlers begin to be socialized to conform with the family and societal norms for their sex, and their self-concepts are influenced by what they sense of how one or the other sex is valued at home. In most respects the sexes are more alike than different, and early sex-role stereotyping may be harmfully constricting when it inculcates mutually exclusive differences, such as avoidance of tenderness in boys or avoidance of assertiveness in girls.

Between 3 and 5 years of age, emotional development and neurobiological maturation cause genital erotic sensations to become much more intense. The child becomes jealous of the parents' sexual intimacy and quite naturally wants to satisfy the new sexual urges with the most-loved opposite-sex person: mother or father (the Oedipus complex). At the same time, children feel guilty about their wishes to get rid of the same-sex parent whom they also love. The healthy outcome of this inner conflict is that the child relinquishes the desire to displace the same-sex parent and instead firmly and definitively identifies with mother or father.

Obscure as this conflict is, the support of parents' realistic attitudes as a corrective to the child's exaggerated fantasies is crucial to healthy sexual development. Unfortunately, some parents become uneasy over their child's often blatant sexuality and either withdraw or sharply disapprove of it; to the child, this kind of reaction confirms that the newly experienced heterosexual wishes are bad and dangerous. If the parents are welcoming toward the child's budding sexuality, while gently indicating that the desires must be deferred until later and to a more appropriate future partner, the child will achieve a major component of sexual identity. The child will have learned that he or she has the right to heterosexual desires, to eventual competition for a partner, and to sexual fulfillment. It is probable that future heterosexual or homosexual object choice is determined during this stage.

Late Childhood

The most intense cultural socializing toward accepted sex-role norms is during the early school years. The child now confronts the broader community's expectations of future men and women. In their identification with parents and adults of the same sex, children learn how males and females are supposed to act and feel, how they regard one another, and what the accepted ranges of interests and future occupations are for each sex; children are discouraged, punished, or ridiculed for deviations from the local norm. Wide divergence in the details of masculine and feminine norms occurs in different cultures, but most cultures intuitively socialize children to sex roles that are consonant with innate propensities and natural complementary life functions.

Puberty

Puberty is the surge of biological maturation that culminates in reproductive capacity and relatively adult body size and contour; adolescence is the psychosocial response to puberty. Puberty occurs about 2 years earlier for girls than for boys, and the full span of bodily changes may require from 1½ to 4 years. Usually in girls at about 10 to 11 years of age the sex hormone estrogen is produced in an increasing amount by the maturing ovaries, initiating breast and uterine development and the typical distribution of fat that results in characteristic feminine body contours. Females also produce the male hormone androgen, which is responsible for the development of pubic and axillary hair and the enlargement of the clitoris and labia majora. Androgen is also responsible for erotic desire and the intensity of genital sensation in women. At about the midpoint of this process (average 12–12½ years), the hypothalamus has begun its cyclic regulation of sex hormones and the first MENSTRUATION occurs.

In boys the testicles begin to enlarge at about 12 years and about a year later begin to produce increasing amounts of testosterone. This production initiates growth of the penis, pubic hair, and prostate, and deepening of the voice, and it is responsible for the characteristic male musculature and heavier, broader bone growth. The ability to ejaculate semen with viable sperm—the male equivalent of first menstruation—usually comes slightly before 14 years of age.

Adolescence

The change from a child to a person with an adult body and sex drives places stress on most individuals, in Western society at least, and the years of adolescence are required for integration. Girls are often readier to relate socially to older boys because of their male peers' lag in maturation. Boys tend to band together and avoid girls early in adolescence. The Oedipal attraction to opposite-sex parents reemerges and contributes to both sexes going through a phase of intense emotional distancing from parents. The surge of sex hormones tends at first to intensify male/female differences, and even most ex-tomboys become more traditionally feminine as that surge is reinforced by male peers. Society, too, increases its pressure for conformity to its preferred norms of masculinity and femininity.

In the West, prohibitions of normal childhood sexuality and inadequate sex education ill prepare children for the stronger sexual feelings of puberty. The need for sexual exploration, though, is powerful, and masturbation increases. Masturbation is healthy and beneficial in providing means for learning about an individual's body and sexual responses and correlates positively with later sexual response with a partner. The earliest sexual activity with others is more often with friends of the same sex, because they are more familiar and less anxiety-producing; this kind of homosexual activity seldom indicates future homosexuality but may worry the participants and parents. As they become more secure, youngsters begin heterosocial activities.

The trend recently has been for adolescents to begin sexual activity earlier. Once youngsters begin petting and genital fondling, they will usually experiment with intercourse within a few months, although some do not and remain virgin until adulthood or marriage. Although masturbation remains the chief mode of sexual release throughout adolescence, even for those who are heterosexually active, a few begin intercourse by 12 to 13 years. By the end of the teens a clear majority of young people have had intercourse at least once.

In early adolescence the newly intense sex drive and a person's own body and responses are so unfamiliar that sexual activity is mainly self-centered, even when with a partner. The adolescent may believe he or she is devoted, but the real developmental need is to explore one's own sexual functions, sensations, and responses. With experience these become familiar and secure, and one turning point into late adolescence is the emotional capacity to shift focus to the partner, the relationship, and the meaning of emotional involvement.

Adulthood

Sexual development does not end with adolescence but continues through life. Young adults expand their emotional development to cope with extended commitment to another person and balance their sexual drives with their sexual values. Marriage adds the new dimension of trying to synchronize two persons' sexual development to maximize the positive bond and minimize disruption. Children trigger a whole new cycle of sexual development. As children go through each sexual development phase, it reawakens unfinished emotional business from that phase in the parent, permitting further growth that benefits both generations.

In their late forties and early fifties most women cease menstruating and can no longer bear children. For a minority this time is difficult; women in this group feel their usefulness is over, especially if having children was their only source of self-approbation. Most women, however, take it in stride or even discover a new freedom. There is no such sudden decline in male fertility, men having fathered children when in their nineties. Men may also experience emotional crisis, however, if they feel in danger of losing vigor and sexuality.

In Western culture there is a myth that older people are not, and should not be, sexual. This notion is untrue; only the imperative nature of the drive gradually relaxes. With an available compatible partner and in the absence of severe physical disorder, full sexual gratification is a fulfilling interaction to the end of life.

See also: SEX; SEX EDUCATION.

sexual intercourse

In mammals, the strict biological definition of sexual intercourse, or coitus, is the insertion of the male's erect penis into the female's vagina, to impregnate the female. The traditional definition of human sexual intercourse is also penile-vaginal penetration for the purpose of conceiving a child, but broader definitions include the insertion of a penis into an oral, anal, or vaginal opening, and a wide variety of behaviors that may or may not include penetration, including intercourse between members of the same gender.

People engage in sexual intercourse for a variety of reasons beyond the need to conceive a child. It can be an intimate form of communication between people, giving physical and emotional pleasure, including orgasm. Orgasm is a complex reaction of physical reflexes and powerful emotions lasting from a few seconds to a minute or more, followed by a feeling of physical and emotional relaxation and relief. Female orgasm exists in a variety of forms, from a single episode of mildly pleasurable rhythmic contraction of the uterine and vaginal walls to multiple episodes of extreme intensity that involve the entire body and can last for minutes or reoccur for hours. Male orgasm can also vary in intensity, duration, and frequency. For men, orgasm is usually precipitated by a series of penile thrusts, accompanied by contractions of the prostate and muscles surrounding the penis, elevation of the testes, and ejaculation.

The Sexual Response Cycle

The human sexual response cycle has been outlined as a four-phase process: excitement, plateau, orgasm, and resolution. The excitement phase may last from a few minutes to several hours. During the excitement phase and the plateau phase that follows, both women and men experience increased muscle tension and heart rate, a sex flush (blotches on the skin of the chest and neck), nipple erections, and vasocongestion of the genitals that leads to the swelling of the clitoris and labia minor (inner lips) for women, and erection of the penis for men. The woman's breasts enlarge, her vaginal walls "sweat" a lubricating fluid, and her uterus elevates and increases in size. The outer third of a women's vagina swells, and the muscle that rings the vaginal opening tenses. Together they form the "orgasmic platform." In men the testes elevate and increase in size, the scrotal skin thickens, and the Cowper's glands (pea-sized organs located below the prostate gland) secrete a clear lubricating fluid.

The phases of sexual response are not necessarily distinct, and the clitoris and labia or penis may not become erect until the plateau phase. The clitoris may become painful to the touch as it withdraws under its hood. During the plateau phase the responses begun in the excitement phase may deepen in intensity.

During the orgasmic phase both women and men experience involuntary muscle spasms, peak blood pressure and heart rate, rapid breathing, contractions of the rectal sphincter, carpopedal spasms in the feet, and a sudden discharge of sexual tension. Female orgasms are characterized by multiple rhythmic contractions (approximately 0.8 seconds apart) of the uterus and the orgasmic platform that grips the penis during intercourse and facilitates orgasm for both men and women. Some women also experience the ejaculation of fluid during orgasms that are produced by the stimulation of the Grafenberg (G) spot. The G spot is located approximately an inch inside the vagina on the anterior wall. Stimulating the G spot may trigger the production and expulsion of fluid from the Skene's gland.

There is some debate as to whether orgasms attained by vaginal stimulation are different from those attained by clitoral stimulation alone. Masters and Johnson maintain that only one kind of physical female orgasm exists, whether the clitoris, the vagina, or both are stimulated. Other researchers suggest that there are at least three different kinds of female orgasm: the vulval orgasm, primarily from clitoral stimulation, the uterine orgasm, primarily from vaginal penetration and stimulation of the G spot, and the blended orgasm, from a combination of stimuli.

For men, orgasm is usually accompanied by ejaculation. A single ejaculate contains about 300 million sperm in a fluid called semen. Ejaculation is a two-phased process. In the emission phase, seminal fluid accumulates in the urethral bulb of the prostate, resulting in a sensation of ejaculatory inevitablility. In the expulsion phase, the neck of the urinary bladder closes to ensure that no urine will mix with the semen, and the muscles at the base of the penis and of the penile urethra contract at intervals of approximately 0.8 seconds to force the semen out of the opening. Some men experience a dry ejaculation as a result of genetics, illness, medication, surgery, or damage to the valves of the urethra that control the flow of semen, allowing the ejaculate to empty into the bladder instead of being expelled out of the penis.

During the resolution phase, both females and males return to normal levels of muscle tension, heart rate, and blood pressure. The sex flush vanishes, nipple erection subsides, and the vasocongestion that caused the swelling of the labia and clitoris, and the erection of the penis, disappears. In women the clitoris descends from under its hood and becomes less sensitive, vaginal lubrication ceases, breasts return to their normal size, the orgasmic platform dissipates, and the uterus returns to its pre-aroused state. In men the testes return to their normal size, the skin of the scrotal sac relaxes, and the Cowper's glands stop their secretions. Although many women and some men can move quickly through excitement, plateau, and orgasm again, most men experience a refractory period after orgasm and are not able to reexperience erection and orgasm again for a time ranging from a few minutes to days, depending on age, genetics, and health.

The physiological differences of sexual response between genders can be enormous. But the experience of orgasm for both women and men is so similar that researchers are unable to determine the gender of the author in written descriptions of orgasmic experience.

Sexual Desire

The desire for sexual expression varies greatly from one individual to another. Sexual expression is influenced by a multitude of factors, such as feelings of attractiveness, availability of a partner, personal power, economics, cultural attitudes, genetics, religious beliefs, age, health, and gender. Research has documented that humans have the capacity to enjoy and engage in sexual activity throughout their lives. Almost everyone expresses themselves sexually (ranging from several times a day to only a few times in a lifetime) through masturbation, intercourse, and other activities, depending on their level of desire and other factors that influence their behavior.

See also: REPRODUCTIVE SYSTEM, HUMAN.

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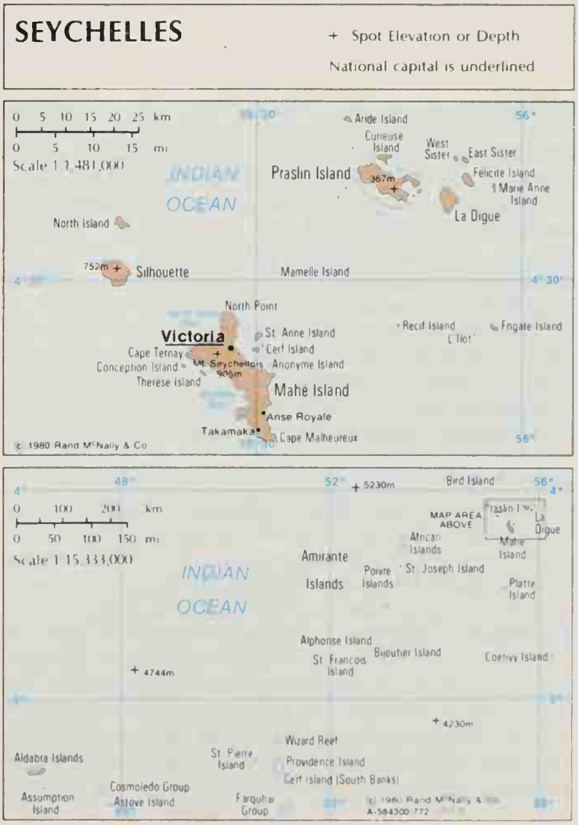
sexual selection *Sexual selection* is a term that refers to the advantage that certain individuals have over others of the same sex and species with respect to reproduction. Sexual selection can result either from a preference shown by the female for certain individuals among competing males or from an interaction among competing males that results in one male preventing the others from mating. Competitive mating systems occur among many species of animals because of an excess of males in relation to females. Polygamy, or the exclusive mating of many females to one male, occurs in some species and further accentuates competition among males.

Charles Darwin (1809–82) placed great emphasis on sexual selection as one of the important forces in the evolutionary process. He realized that any inherited traits resulting in a higher survival and reproductive rate for some individuals would be transmitted to the offspring.

Since Darwin's time, sexual selection has been studied in such animals as deer, baboons, birds, and seals. One study involving the northern elephant seal, *Mirounga angustirostris*, revealed that during the breeding season males fight each other in order to establish their social rank. This hierarchy determines which males have access to females, who live in harems. During a typical breeding season, 4% of the males mate with 85% of the females, indicating the strong pressure of sexual selection among the males of this species.

Seychelles [say-shelz'] The Republic of Seychelles is an archipelago located in the Indian Ocean, about 1,450 km (900 mi) off the east coast of Africa. It became independent from Great Britain in 1976.



AT A GLANCE

REPUBLIC OF SEYCHELLES

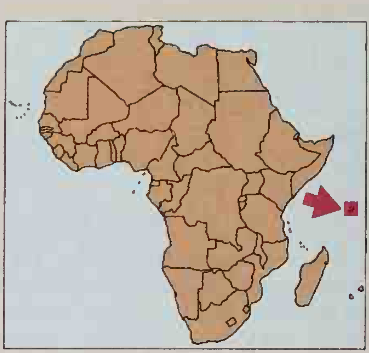
Land: Area: 453 km^2 (175 mi^2). Capital and largest city: Victoria (1984 est. pop., 23,000).

People: Population (1990 est.): 68,336. Density: 150.9 persons per km^2 (390.5 per mi^2). Distribution (1989): 52% urban, 48% rural. Official language: Creole. Major religions: Roman Catholicism, Anglicanism.

Government: Type: one-party state. Legislature: People's Assembly. Political subdivisions: none.

Economy: GNP (1989): $285 million; $4,170 per capita. Labor distribution (1985): agriculture—9.5%; mining and manufacturing—7.0%; construction—4.4%; public utilities—2.6%; transportation and communications—9.4%; trade—12.8%; finance—3.4%; public administration, defense, and services——15%; other, including unemployed—35.8%. Foreign trade (1988 est.): imports—$116 million; exports—$17 million. Currency: 1 Seychelles rupee = 100 cents.

Education and Health: Literacy (1983): 60% of adult population. Universities (1989): none. Hospital beds (1988): 353. Physicians (1988): 68. Life expectancy (1990): women—75; men—65. Infant mortality (1990): 15 per 1,000 live births.



Land, People, and Economy

The largest of the 92 islands and islets comprising Seychelles are Mahé and Praslin. About half of the islands are volcanic in origin, with narrow coastal strips and central ranges of hills rising to 914 m (3,000 ft). The other half are coral atolls, many uninhabitable. The annual mean temperature in Victoria on Mahé is 27° C (80° F); annual rainfall averages 2,337 mm (92 in).

Most Seychellois are of mixed European, Asian, and African descent. Creole (a French patois) has been the official language since 1981. About 90% of the inhabitants are Roman Catholic. Free health services are provided by government-run clinics and hospitals, and nine years of primary education have been free and compulsory since 1979.

Much of the population is engaged in subsistence agriculture and fishing. Coconuts, cinnamon, vanilla, and patchouli (used in perfumes) are raised for export. Industry is limited to food processing and the manufacture of light consumer goods. Tourism replaced agriculture as the largest contributor to the gross national product in 1975. In 1989 nearly 90,000 tourists visited the Seychelles, attracted by its fine beaches, warm climate, and scenic beauty. Tourism and the rapidly expanding fishing industry are important sources of foreign exchange and jobs in a country that has a large trade deficit and high unemployment.

History and Government

The Seychelles islands were first charted by the Portuguese as early as 1505, although Arab traders may have visited them previously. In 1742 the French took possession, and French settlement began during the 1770s. The islands officially passed into British hands by the Treaty of Paris in 1814. Under both the French and the British, the islands were regarded as a dependency of Mauritius, an island located about 1,800 km (1,100 mi) to the southwest. In 1903, Seychelles became a separate British crown colony, and on June 29, 1976, an independent republic.

In 1977 a group of rebels overthrew the government, installing Albert René, a socialist, as the new president. René briefly suspended the 1976 constitution and modified it, giving the president the power to rule by decree. A new constitution, establishing a one-party state, came into effect in March 1979. René, whose government has survived several coup attempts, was elected to a third five-year term in 1989.

Seyfert galaxies see EXTRAGALACTIC SYSTEMS

Seymour, Horatio Horatio Seymour, b. Pompey Hill, N.Y., May 31, 1810, d. Feb. 12, 1886, was twice Democratic governor of New York (1853–54, 1863–64).

He asserted that the Emancipation Proclamation was illegal, opposed federal conscription as an unwarranted violation of state rights, and claimed that the draft law discriminated against New York City. In July 1863, during the DRAFT RIOTS in the city, Seymour made a conciliatory speech that led Horace Greeley to denounce him as a Copperhead (a Southern sympathizer), a charge that contributed greatly to his defeat for reelection. Among Seymour's successes as governor was the improvement of the state's penal system. The Democrats nominated Seymour as their presidential candidate in 1868, but he lost to Ulysses S. Grant.

Seymour, Jane Jane Seymour, b. *c.*1509, d. Oct. 24, 1537, was the third wife of HENRY VIII of England and the mother of EDWARD VI. Henry became attracted to Jane when she was lady-in-waiting to Anne BOLEYN, his second wife. He married Jane in 1536, 11 days after Anne's execution. Jane gave Henry the male heir he so ardently desired but lived only 12 days after his birth. Her brothers, the 1st duke of SOMERSET and Baron Seymour of Sudeley, rose to power during Edward's reign.

Sfax [sfahks] Sfax (Arabic: Safaqis), the second largest city of Tunisia and a major commercial and fishing port, lies about 240 km (150 mi) south of Tunis. The population is 231,911 (1984). Exports include phosphates, mined at the nearby Gafsa, olive oil, and dates. The old Arab quarter, with a 10th-century mosque, is surrounded by 9th-century ramparts. Phoenicians settled in the area in the 9th century BC, and Romans arrived in 149 BC. Occupied by Sicilian Normans in 1148, the city was taken by the Spanish in the 16th century and became a French protectorate in 1881. The Axis powers held Sfax during World War II until 1943, when it was liberated by the British.

Sforza (family) [sfort'-sah] The Sforza family ruled in Milan and Lombardy between 1450 and 1535. The founder of the dynasty was **Muzio Attendolo**, b. May 8, 1369, d. Jan. 4, 1424, a peasant farmer who achieved his fortune as a CONDOTTIERE, or mercenary soldier. He took the surname Sforza, which means "force." His son, **Francesco I Sforza**, b. July 23, 1401, d. Mar. 8, 1466, conquered Milan in 1450, through the claim of his wife, Bianca Maria Visconti, the illegitimate daughter of the last Visconti lord of Milan. Francesco's second son, **Ludovico Sforza**, b. July 27, 1452, d. May 27, 1508, called "Il Moro" because of his swarthy complexion, was one of the most magnificent of the Renaissance princes. Ludovico became duke of Milan in 1480. In 1494 he sought the aid of Charles VIII of France against Florence and Naples, thus facilitating the French invasion of Italy, but the French soon turned against him, and he lost Milan to King Louis XII in 1499. Captured by the French, Ludovico was imprisoned in the castle of Lorches, France. With his wife, Beatrice d'Este, Ludovico was the patron of several great Renaissance artists, including Leonardo da Vinci. His older son, **Massimiliano Sforza**, 1493–1530, retook Milan in 1512, but he was defeated at the Battle of Marignano (1515) and had to cede Lombardy to France. Ludovico's second son, **Francesco II Sforza**, b. 1495, d. Oct. 24, 1535, received Milan from Holy Roman Emperor Charles V in 1522 and ruled until his death without heir. Lombardy passed to the Spanish Habsburgs.

Caterina Sforza, b. *c.*1463, d. May 28, 1509, was the wily countess of Forlì, which she defended from the papacy after the death of her first husband, Girolamo Riario, in 1488. Married to Giovanni de'Medici in 1498, Caterina was driven into exile by Cesare Borgia.

Shaanxi (Shensi) [shan-see] Shaanxi, a province in east central China, covers 195,800 km^2 (75,600 mi^2) and has a population of 32,882,403 (1990). The capital is XI'AN. The mountainous southern region consists of the Daba Shan, with elevations of 1,500 to 2,400 m (5,000 to 8,000 ft), and the Qin Ling Shan, which averages 2,400 m (8,000 ft) in height. Central Shaanxi is dominated by the Wei He valley. The northern region is a plateau, mostly above 900 m (3,000 ft). The major rivers are the Wei, Jing, and Han. The fertile soils support grains, fruits, and tobacco. Iron ore, coal, and petroleum deposits are worked.

Shaanxi was one of the earliest political centers of northern China, and the Zhou, Qin, Han, and Tang dynasties had their capitals there. The province declined during the 19th century after a series of rebellions and drought. The Communist army came to Shaanxi on its LONG MARCH in 1935, and from then to 1949, Shaanxi was the seat of the Chinese Communist government.

Shaba [shah'-bah] Shaba is a province in southeastern Zaire with a population of 4,444,162 (1990 est.). One of Africa's richest mining areas, Shaba covers 496,877 km^2 (191,845 mi^2). LUBUMBASHI is the capital city. Shaba is mainly a high plateau, with Kundelurgu Peak reaching 1,600 m (5,250 ft). The province has deposits of copper, coal, gold, cobalt, silver, tin, and manganese. Tobacco, cotton, and palm oil are grown.

Shaba, which was known until 1972 as Katanga, was ruled by Belgium as part of the Belgian Congo from 1885 to 1960, when the Congo (later Zaire) became independent. Less than a month later Katangan rebels under the leadership of Moise Kapenda TSHOMBE seceded from the new nation, but the province was finally restored (1963) to the Congo after intervention by United Nations troops.

Shackleton, Sir Ernest Henry [shak'-ul-tuhn] Sir Ernest Henry Shackleton, b. Feb. 15, 1874, d. Jan. 5, 1922, was a British explorer. He was a member of the

1901–04 expedition to Antarctica led by Robert Falcon Scott. Shackleton returned to the Antarctic in January 1908 with his own ship, *Nimrod*. Members of his party reached the summit of volcanic Mount Erebus (3,794 m/ 12,448 ft) and located the South Magnetic Pole. On his 1914 expedition, while attempting to cross Antarctica from the Weddell Sea to the Ross Sea, his ship was crushed by ice, and the party escaped in boats to Elephant Island. Shackleton sought rescue for his men by sailing to South Georgia Island; they were rescued in 1916.

shad [shad] Shad are herringlike schooling fishes with silvery scales and compressed, deep bodies. Most are members of the family Clupeidae. Four such species are native to the U.S. coasts of the Atlantic and Gulf of Mexico, and two such species (*Alosa alosa* and *A. fallax*) live in European waters and the Mediterranean. Most feed on plankton as well as on fish and inhabit marine or brackish water as adults, migrating in the spring to spawn in larger rivers, where the eggs can drift downstream. Shad hatch in 2–15 days, and the larvae move upstream again, where they spend their first summer. Some species have established permanent freshwater populations, such as the skipjack herring, *A. chrysochloris*, in the Mississippi River Valley. The gizzard shad, family Dorosomidae, does not migrate to spawn.

The American shad, *A. sapidissima*, was introduced on the west coast of the United States in the later 1800s and rapidly proliferated in San Francisco Bay and tributary streams. On both coasts substantial commercial fishery existed for shad in the first half of the 20th century, but overfishing and environmental change have reduced the shad's numbers.

shadow play Brought to the West by 17th-century travelers, the shadow play is an East Asian form of puppetry in which flat cutout figures are silhouetted against a translucent screen. Developed in China, probably about 100 BC, shadow puppetry spread as far as North Africa and Turkey, then to Greece, its most famous version being the plays of Bali and Java. These plays present incidents from Hindu epics with buffalo-skin figures, whose grotesque shapes and ornamentation are prescribed by tradition. In performances lasting up to ten hours, the puppeteer manipulates the figures with rods and intones the story to musical accompaniment.

Shadwell, Thomas [shad'-well] The English dramatist and poet Thomas Shadwell, b. *c.*1642, d. Nov. 19, 1692, succeeded his enemy John Dryden as poet laureate in 1688. He wrote many successful comedies in the style of Ben Jonson and produced an opera, *The Enchanted Island* (1674), based on William Shakespeare's *The Tempest*.

Shaffer, Peter [shaf'-ur] Peter Shaffer, b. May 15, 1926, is an English dramatist whose varied and experimental work has attained popular acclaim. He established his reputation with *Five Finger Exercise* (1958; film, 1962) and *The Royal Hunt of the Sun* (1964; film, 1969). *Equus* (1973; film, 1977) examines the human need for myth and religion. *Amadeus* (1980, Tony Award; film, 1984, several Academy Awards) is a fictional portrait of the relationship between Mozart and his jealous rival Antonio Salieri.

Shafter, William Rufus [shaf'-tur] William Rufus Shafter, b. Galesburg, Mich., Oct. 16, 1835, d. Nov. 12, 1906, was a brigadier general who commanded U.S. troops in the invasion of Cuba in June 1898, during the Spanish-American War. Although his men took Santiago on July 17, 1898—effectively winning the war—Shafter was criticized because the expedition was poorly prepared and equipped. Many of the difficulties may have been beyond his control.

Shaftesbury, Anthony Ashley Cooper, 1st Earl of [shafts'-bree] The English statesman Anthony Ashley Cooper, 1st earl of Shaftesbury, b. July 22, 1621, d. Jan. 21, 1683, led the opposition to Charles II in Parliament and is credited with founding England's Whig party. During the English Civil War he was at first a royalist, but in 1644 he joined the parliamentarians and later became a member of Oliver Cromwell's council of state. He helped to restore (1660) Charles II and became (1661) Charles's chancellor of the exchequer. A member of the group of ministers called the Cabal, he was created earl of Shaftesbury and appointed lord chancellor in 1672.

Shaftesbury was determined to prevent the succession of the king's Roman Catholic brother, the duke of York (later James II), and pressed Charles to divorce his barren wife and remarry or to legitimize the duke of Monmouth, Charles's illegitimate son. In 1673, Shaftesbury was dismissed as chancellor and joined the opposition in Parliament. In 1681 his legislative attempts to exclude the duke of York from the succession were defeated, and he then turned to conspiracy. Shaftesbury was tried for treason but acquitted (1682). He fled to Holland, where he died. He was one of the founders of Carolina, the British proprietary colony in North America that later became the states of North and South Carolina.

Shaftesbury, Anthony Ashley Cooper, 3d Earl of Anthony Ashley Cooper, 3d earl of Shaftesbury, b. Feb. 26, 1671, d. Feb. 15, 1713, was an influential English philosopher. A grandson of the 1st earl, he was tutored by John Locke and could read Latin and Greek at the age of 11. On the Continent from 1686 to 1689, he learned French and cultivated a taste for painting, sculpture, and music. He served (1695–98) in the House of Commons and in 1699, on inheriting the earldom, entered the House of Lords. In the same year he published the essay "An Inquiry concerning Virtue."

Shaftesbury was the first English philosopher to argue for a "moral sense," an innate awareness of good and evil. Morality, he said, stemmed from human nature itself, prior to all positive law and religion. Religion is the outcropping of morality rather than its source. The inborn moral sense is akin to an aesthetic sense by which all can perceive the beautiful. Natural instincts are good, but they can be perverted. Society is natural and not the result of a social contract.

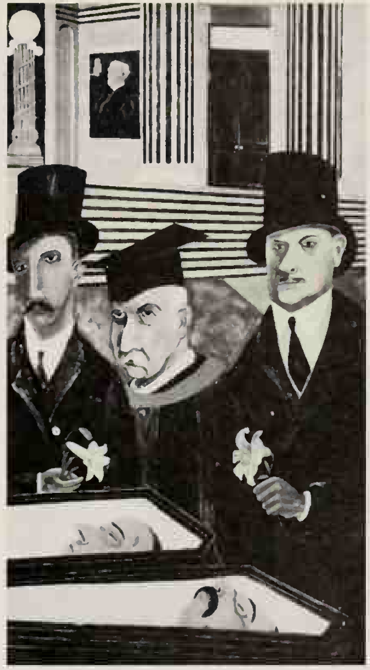
Shaftesbury, Anthony Ashley Cooper, 7th Earl of A British statesman and philanthropist, Anthony Ashley Cooper, 7th earl of Shaftesbury, b. Apr. 28, 1801, d. Oct. 1, 1885, guided a succession of important social reforms through Parliament. He sat in the House of Commons from 1826 until 1851, when he succeeded to the earldom, and thereafter sat in the House of Lords. Shaftesbury was active in securing the passage of regulations for factories and coal mines that alleviated the worst exploitation of workers, particularly women and children. He also fought to improve working-class housing and was chairman for 39 years of the Ragged School Union, an organization that created schools for poor children.

Shah Jahan, Mogul Emperor of India [juh-hahn'] Shah Jahan, b. Jan. 5, 1592, d. Jan. 22, 1666, was a MOGUL ruler of India (r. 1628–58), best known as the builder of the TAJ MAHAL at Agra. The third son of the emperor JAHANGIR, he left his father's court in 1622. When his father died, Shah Jahan returned to court, had his male relatives killed, and became emperor in 1628. He rapidly expanded his territory, conquering Ahmadnagar, Golconda, Bijapur, and other nearby areas. In 1638 he took Kandahar; in 1646 he pushed into northern Afghanistan. Having amassed an enormous fortune, he moved the capital to Delhi. He made Islam the state religion, but he was tolerant of Hinduism.

Shah Jahan's fame today largely results from the splendor of the Mogul art and architecture of his reign. His son, AURANGZEB, usurped the throne in 1658 and imprisoned Shah Jahan in Agra Fort until his death. He is buried in the Taj Mahal next to his favorite queen, Mumtaz Mahal.

Shah Namah see FIRDAWSI

Shahn, Ben One of America's most notable social realists, Ben Shahn, b. Lithuania, Sept. 12 (N.S.), 1898, d. Mar. 14, 1969, established his personal style in his series of paintings (1931–32) inspired by the political sentiments aroused by the Sacco-Vanzetti case. Although he had worked in lithography since 1913, those paintings brought Shahn his first great success and are still, perhaps, his best-known achievement. Combining the precision of commercial lithography with the manipulation of color, form, and perspective he had admired in modern European painting, Shahn developed a unique approach that he often placed at the service of liberal causes. In the early 1930s, while assisting Diego RIVERA, he became interested in mural painting; it was also during this period that he took up photography. In the 1940s, moved by the plight of wartime Europe, Shahn devoted a series of paintings to this tragedy. Toward the end of his life, Shahn's work became more abstract.



The Passion of Sacco and Vanzetti *is one of a series of 23 paintings (1931–32) Ben Shahn created in outraged response to the trial (1921) and execution (1927) of Nicola Sacco and Bartolomeo Vanzetti, two Italian anarchists accused of murder in a controversial case never clearly resolved. This series, Shahn's first major success, reflects the concern with political and social justice that remained the primary focus in much of his later work. (Whitney Museum of American Art, New York City.)*

Shaka, King of the Zulus [shah'-kah] Shaka (Chaka, Tshaka), b. *c.*1787, d. Sept. 22, 1828, was the greatest of Zulu conquerors. Shaka rose to become one of the military commanders of the Zulu leader Dingiswayo. When Dingiswayo was murdered by the Ndwandwe, a rival clan, Shaka assumed the throne. Shaka reorganized the Zulu state and shaped its army into a powerful striking force without rival among the African kingdoms of southern Africa. Shaka's bloody wars of conquest occasioned far-flung tribal migrations to such distant places as present-day Zimbabwe and Tanzania. Although Shaka maintained basically friendly relations with Europeans, including the Cape government, his cruelties aroused opposition within his own kingdom. He was murdered at Dukuza, his military capital, by his half brothers Dingane and Mhlangana. He remains a hero to the Zulus.

Shakers Beginning in England at a Quaker revival in 1747, the United Society of Believers in Christ's Second Appearing, also known as the Millennial Church, or the Alethians, came to be called Shakers because of the trembling induced in them by their religious fervor. Led by James and Jane Wardley, the so-called Shaking Quakers were a minor religious sect until Ann Lee became the head of the movement.

Mother Ann, as she was known, believed that she had received the feminine principle of the deity. Immigrating to the United States, she established (1776) a community at Watervliet, N.Y. By 1826 there were 18 Shaker communities with about 6,000 members in 8 states. Their peak period was 1840–60. As revivalism declined after the Civil War, so did the fortunes of the communities. By 1980 the Shakers were almost extinct.

The Shakers believed in Mother Ann as the source of God's fullest revelation to humankind. Other doctrines and practices included celibacy, open confession of sins, communal sharing of possessions, pacifism, equality of the sexes, and consecrated labor. Members rejected Calvinist ideas of predestination and emphasized free will. In their well-organized, self-sufficient communities segregated from the outside world, the Shakers worshiped in unusual ways; dancing, ecstatic shouting, and trances were held to be proof of the Holy Spirit's presence.

The furniture and other goods that the Shakers made for themselves are remarkable for simplicity of design and fine craftsmanship.

Shakespeare, William The English dramatist and poet William Shakespeare was the author of the most widely admired and influential body of literature by any individual in Western history. His work comprises 36 plays, 154 sonnets (see Sonnets of Shakespeare), and 2 narrative poems.

Life. Shakespeare was baptized in Holy Trinity Church, Stratford-upon-Avon, Warwickshire, on Apr. 26, 1564. He is buried in the same church, where a memorial records his death on Apr. 23, 1616. In 1623 his colleagues John Heminge and Henry Condell created another memorial by publishing *Mr. William Shakespeares Comedies, Histories, and Tragedies*, the collection of his plays now known as the First Folio.

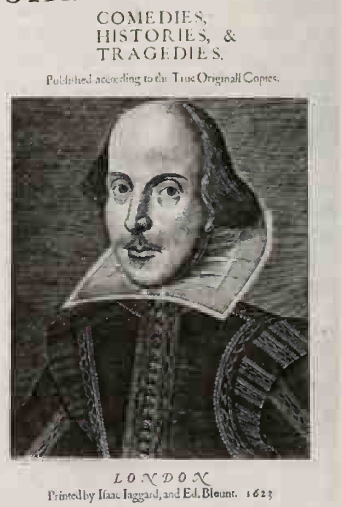
Shakespeare probably attended Stratford's excellent free grammar school, although no record of the fact exists. On Nov. 28, 1582, church authorities gave permission for him to marry Anne Hathaway of the neighboring village of Shottery. He was 18 years old, and she was 26; probably she was pregnant. On May 26, 1583, their daughter Susanna was baptized in Holy Trinity. Twins, named Hamnet and Judith, were baptized on Feb. 2, 1585.

No records have been found for the years between the twins' baptism and 1592. In that year a disappointed author, Robert Greene, referred cryptically to Shakespeare in his *Groatsworth of Wit Bought With a Million of Repentance*; he warned his fellow writers about "an upstart crow, beautified with our feathers, that with his *Tiger's heart wrapped in a player's hide*, supposes he is as well able to bombast out a blank verse as the best of you: and being an absolute *Johannes fac totum*, is in his own conceit the only Shake-scene in a country." Thus as early as 1592, Shakespeare was sufficiently well known to be recognized by the pun on his name and the parody of a line from his *Henry VI, Part 3:* "O tiger's heart wrapped in a woman's hide."

Unlike Greene, Shakespeare was an actor ("player") as well as a writer, and he was associated with a group of other actors that included the day's leading comedian, Will Kempe, and a leading tragedian, Richard Burbage. They were known, after their nominal patron, as the Lord Chamberlain's Men and (after 1603) as the King's Men. By 1592, Shakespeare was acting exclusively for this company; he held shares in the company's profits; he was part of a consortium that in 1599 built and owned its home theater, the Globe Theatre; and he wrote his plays exclusively for this company, at the rate of about two per year.

In 1593–94 a plague forced the closing of the London theaters. In those years Shakespeare published two narrative poems, *Venus and Adonis* and The *Rape of Lucrece.* The circumstances surrounding his sonnets are less clear. Scholars are not certain how long before their unauthorized publication (1609) they were written, whether they were all written in the same period, or whether the order in which they appeared was of Shakespeare's design.

Works and Reputation. Shakespeare wrote his plays for performance, not publication, and apparently took no part in their printing. Nineteen plays appeared in individual quarto volumes before appearing in the First Folio. Some were printed from texts reconstructed from memory by an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William Shakespeare, the foremost dramatist and poet of Elizabethan England, is considered by many the most gifted literary figure of all time. His works display a facility for characterization and a command of poetic expression that have never been surpassed. This engraving of Shakespeare by Martin Droeshout was the frontispiece for the First Folio edition.

actor or actors; others were supplied to the printer by the company.

Shakespeare's earliest plays, performed between 1588 and 1593, already show the range of his formal dramatic interests. They foreshadow his mature accomplishments and reveal some of the sources on which he drew for inspiration. His first tragedy, *Titus Andronicus* (*c.*1592–1594), was influenced by the emphasis on extreme psychological states and the rhetorically ornate manner of the Roman playwright Lucius Annaeus Seneca; the influence of Ovid is also felt. Popular in its own day, *Titus* is now often denigrated; its treatment of physical and moral outrage, however, is recalled even in the mature *King Lear.* For the three parts of *Henry VI* (*c.*1588) and for *Richard III* (*c.*1593) he drew on histories of England by Edward Hall (1548) and Raphael HOLINSHED (1587). Shakespeare returned to this material between 1595 and 1600 to write four plays—*Richard II* (1595), *Henry IV, Parts 1 and 2* (1597 and 1598), and *Henry* V (1599)—that tell an earlier part of the history. Shakespeare's history plays reflect the age's horror at the idea of civil war and explore the responsibilities of divinely authorized kingship, pointing forward by implication to the reign of Elizabeth I.

The Comedy of Errors (*c.*1588–*c.*1593) is indebted to the Roman playwright Plautus; with characteristic exuberance, Shakespeare added a second pair of identical twins to the pair in his source. This early play shows a consummate technical ability, and some of its basic concerns—the dispersal and reunion of a family, time's destructive passage and its potential for renewal, imagery of ocean water, strange lands, and voyages—persist into his last play, *The Tempest* (*c.*1610–11). A pervasive source for ideas and language in all his plays was the Bible.

Shakespeare continued to alternate the writing of comedy and tragedy, although comedy is relatively more prominent in the last decade of the 16th century—*Love's Labor's Lost* (1594), *The Merchant of Venice, A Midsummer Night's Dream, Much Ado About Nothing, As You Like It,* and *Twelfth Night*—and tragedy after 1599—*Julius Caesar, Hamlet, Othello, King Lear, Macbeth, Antony and Cleopatra,* and *Coriolanus* (*c.*1608). Shakespeare's interest in experimentation complicates this division and resulted in a group of plays (*c.*1601–*c.*1604) that do not fit neatly into either category: *Troilus and Cressida, All's Well That Ends Well,* and *Measure for Measure.* These plays—and, in some critical accounts, others, including *Hamlet* or *The Merchant of Venice*—have been called problem plays. Near the end of his career he experimented further in four plays now often called the romances: *Pericles* (*c.*1608)—not included in the First Folio and possibly not written entirely by Shakespeare—*Cymbeline* (1609–1610), *The Winter's Tale* (1610–1611), and *The Tempest.* In them, psychological realism is subordinated to an interest in mythic patterns that incorporate both tragedy's deaths and comedy's wondrous reunions.

Shakespeare's achievement was manifold. He developed dramatic techniques for conveying a sense of his characters' psychological identities; his are the first "modern," and enduringly the most vivid, dramatic characters. His language, by turns dense and supple, extended the range of possibilities for prose and verse. In verse he perfected the dramatic blank-verse line explored also by his contemporaries Christopher MARLOWE and Thomas KYD.

The history of Shakespeare criticism and of Shakespeare in the theater is an important part of the cultural history of the modern world. During the early 17th century he was appreciated as a great entertainer, although thought deficient in refinement compared with Ben JONSON. His supposed artlessness was regarded as a virtue during the 18th century, the period in which the first attempts to establish good printed texts were made. Notable editions include those by Nicholas Rowe (1709), Alexander Pope (1723), Lewis Theobald (1733), and Edward Capell (1768). Samuel Johnson's edition (1765) includes his incisive preface and notes. During the 19th century, English and German romantic poets and critics, such as Coleridge and Schlegel, were attracted to Shakespeare's psychologically complex characters. No one school of thought dominates 20th-century Shakespeare criticism, but interest in Shakespeare as a poet, which leads to close study of his language, complements interest in his plays as living works for the stage.

See also: separate articles on many of the plays.

Shakti [shuhk'-tee] In certain systems of Hindu philosophy and religion, notably types of Shaivism and Tantrism (see HINDUISM), Shakti (a Sanskrit word meaning "power") is worshiped as the mother goddess, SHIVA's dynamic female aspect. One of the major cults of modern Hinduism, especially popular in northeastern India, Shaktism considers the female aspect of the divinity the Supreme Power or Energy. In the Tantric (see TANTRA) form of YOGA known as Layayoga, shakti refers to the life-power that lies coiled like a snake (*kundalini*) and may be aroused by yogic practices culminating in samadhi, or identification with Shiva, constituting liberation.

shale Shale is a fine-grained terrigenous SEDIMENTARY ROCK, the lithified equivalent of mud, which is a sediment consisting of clay- and silt-size particles. Such rocks are classified in terms of particle size, proportion of clay minerals, or fissility (the property of splitting easily along bedding planes into thin layers). Most shales contain from 25 to 50 percent quartz; in coarser shales, quartz and feldspar together make up more than 50 percent of the rock.

Fine-grained terrigenous sedimentary rocks that have abundant proportions of quartz and feldspar particles of silt size, and that by virtue of the abundance of these particles closely resemble sandstones, are commonly referred to as siltstones. Siltstones, however, generally lack fissility. By contrast, fine-grained shales contain an abundance of clay minerals, which are generally oriented parallel to the bedding and thus impart fissility. Fine-grained shales are thus quite different from sandstones not only in particle size but also in physical characteristics.

shale, oil Oil shales are fine-grained sedimentary rocks that are rich in carbonaceous organic matter and yield oil when heated. Under ordinary conditions, oil shale is not visibly oily, but when heated to about 500° C (900° F) some of the organic material is transformed into an oil resembling crude oil. Oil shales, a vast potential energy resource, vary in richness, yielding from 4 to 50 percent oil by weight.

Composition, Classification, and Distribution. Some oil shales are genuine shales—that is, they are composed principally of layers of clayey sediment that split apart readily—but others are actually siltstones, impure limestones, or even impure coal. The organic matter in oil shales consists of soluble and insoluble fractions.

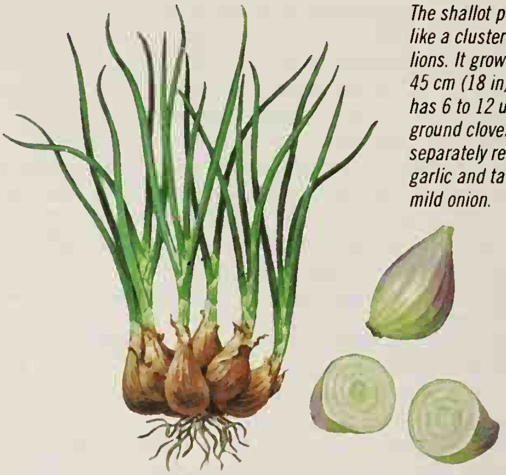
Four general types of oil shale have potential value. Carbonate-rich shale contains the carbonate minerals calcite and dolomite. Siliceous shale, by contrast, is high in silica but low in carbonate. Cannel shale consists of organic material that encloses other mineral grains (chiefly silt and clay); it intergrades with cannel coal but is distinguished by its higher ash content. Marine black shales are rich in organic matter, but not all such rocks are oil shales.

Oil shales were deposited in shallow lakes, marshes, or seas rich in microscopic plant and animal life. Deposits are of widely varying geologic age and occur on all continents, including Antarctica. Marine black shales are widespread in the eastern and central United States, in European USSR, and in southern Brazil. Lake-deposited carbonate-rich oil shales of great potential value occur in China, Yugoslavia, Brazil, Colorado, Utah, and Wyoming.

Extraction. Extraction of oil from oil shale is still in the experimental stage. Most experimental approaches have involved mining the oil shale and transporting it to a retort, where it is heated and the oil extracted. Disposal of the spent shale is a problem because retorting expands the rock, making the refuse more voluminous than the ore itself.

In-situ processing is an experimental alternative. Holes are drilled and the shale is fractured with explosives. Compressed air is pumped in, and the oil shale is ignited. Hot combustion gases flow through the fractures, converting part of the insoluble fraction to oil, which is pumped to the surface.

shallot [shuh-laht'] Shallot is a small, mild-flavored species of onion used as a food flavoring. Its botanical name, *Allium cepa*, is derived from the ancient Palestine city of Ascalon; supposedly, 12th-century Crusaders first brought the bulb from that city to Europe. Shallots are planted and grown like garlic. The short, cylindrical, hollow leaves may be cut for flavoring at any time. In the fall, two to six bulbs are harvested for each one planted. These may be dried and stored like onions.



The shallot plant looks like a cluster of scallions. It grows to about 45 cm (18 in) tall and has 6 to 12 underground cloves, which separately resemble garlic and taste like a mild onion.

Shalmaneser III, King of Assyria [shal-muh-nee'-zur] Shalmaneser III, d. 824 BC, succeeded his father, Ashurnasirpal II, as king of Assyria in 859 BC. His reign was marked by campaigns against neighboring peoples, including the Jews under King AHAB. Jewish envoys to Shalmaneser are shown on his obelisk, now located in the British Museum, London. At the end of his reign, Shalmaneser fought a two-year civil war to quash a rebellion by his son Ashurdaninpal.

shaman [shay'-muhn] A shaman is a religious or ritual specialist, man or woman, believed capable of communicating directly with spirit powers, often while in ecstatic states. The name originated among tribal groups of Siberia, where a shamanistic religion dominates, but shamanic features are prevalent in so many geographically widespread preliterate societies that, for anthropologists, the term *shamanism* has come to refer to a general religious phenomenon. Shamanic power is said to come directly from a supernatural source: a spirit takes possession of the shaman, usually during an ecstasy or trance, and gives the shaman the powers of healing and knowing. A shaman is sometimes called a medicine man among American Indian groups or a witch doctor among various African peoples.

It is the shaman's function to regulate the relations between spirits and the community in order to ensure the community's well-being. Shamans concern themselves with such communal matters as locating and attracting game or fish, finding lost animals or tools, controlling the weather, detecting broken taboos that bring sickness or misfortune, expelling harmful spirits, and planning community activity. In some instances, as among the Eskimo, a shaman may use spirits aggressively, causing injury or death for revenge or in competition with other shamans. Because of such special powers, a shaman can gain considerable political influence in his or her group.

A shaman is said to be chosen by the spirits, selected from among persons of a hysterical temperament who are given to daydreaming and visionary experiences. Sometimes a shaman is marked for the vocation by repeated illnesses or mental disturbance. The person believed chosen for this calling must undergo an initiatory ordeal, which includes an ecstatic temporary loss of consciousness that symbolizes death and resurrection. In many cultures the candidate is believed to receive during this ordeal a mystical light that enables him or her to see far-off things and to discover the secret places to which lost souls have been taken. The recovery of souls is one of the major methods of shamanic curing.

See also: PRIMITIVE RELIGION.

Shamir, Yitzhak Yitzhak Shamir, b. 1914 or 1915, was prime minister of Israel from 1983 to 1984 and again from 1990; he also held that office (1986–88, 1988–90) in two Labor-Likud coalition governments. A native of Poland, Shamir emigrated in 1935 to British-ruled Palestine and in the 1940s was a leader of the Stern Group, a militant anti-British guerrilla organization. A member of the right-wing Herut party, he served (1980–83) as foreign minister under Menachem BEGIN. After the indecisive general elections of 1984 and 1988, Shamir led his Likud coalition into a national unity government with the rival Labor party, led by Shimon PERES. The second Labor-Likud coalition collapsed in March 1990, and Shamir formed a right-wing government in June. During the GULF WAR of 1991, Shamir, heeding U.S. advice, did not retaliate when Iraq fired Scud missiles at Israel.

shamrock Shamrock is the common name for several unrelated herbaceous plants with trifoliate leaves. White clover, *Trifolium repens* forma *minus*, family Leguminosae, was the original shamrock of Ireland; *T. procumbens* is now commonly used. Saint Patrick used the shamrock leaf to symbolize the Trinity, and a trifoliate leaf of this shamrock is worn by the Irish on March 17 to commemorate Saint Patrick's Day. Other species of *Trifolium* are often referred to as shamrocks, as is the species *Oxalis acetosella* in the family Oxalidaceae, a favorite and easily cultured plant for a window garden.

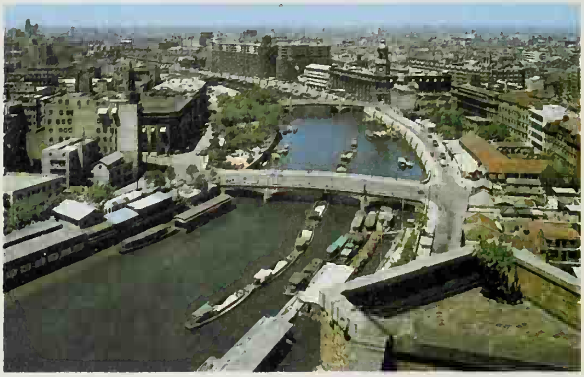
The plant commonly used as Irish shamrock today is yellow clover. On Saint Patrick's Day, March 17, the Irish wear the shamrock as a national symbol of Ireland.

Shan The Shans, one of the more distinctive of Burma's indigenous minorities, have long inhabited the country's eastern plateau, which now forms the Shan state. They have their own alphabet, written language, and literature, and are culturally and physically closer to the neighboring Thai than to the Burmese. In religion they are Buddhist. The number of Shans in Burma (Myanmar) was estimated at 3,510,000—about 8.5% of the population—in 1990. Opium production has become a major economic support for the Shan independence movement.

Shandong (Shantung) [shan-dong] Shandong (meaning "east of the mountains") is a province of east central China astride the lower Huang He (Yellow River) in the North China Plain. Its eastern extremity, the Shandong Peninsula, divides the Bo Hei (Gulf of Zhili) from the Yellow Sea. The province has an area of 153,300 km^2 (59,200 mi^2) and a population of 84,392,827 (1990). JINAN is the capital. Except for the hilly Shandong Peninsula and a central upland area that reaches 1,520 m (5,000 ft), the province consists mainly of vast plains. The GRAND CANAL bisects the eastern part. Marginal precipitation amounts are a threat to crops—predominantly cotton, sorghum, soybeans, tobacco, and wheat. Aluminum, coal, and iron-ore mining and processing are all important to the economy. The peninsula's excellent harbors provide China with some of its best naval bases. Shandong was the home of Confucius.

Shang (dynasty) [shahng] Recent archaeological research continues to illumine the Shang (or Yin) dynasty of China, which succeeded the XIA (Hsia) dynasty (*c.*2205–*c.*1766 BC) and is traditionally dated *c.*1766–*c.*1122 BC. Excavations, particularly at the site of the last Shang capital near modern Anyang in Henan province, have confirmed descriptions in ancient Chinese literature of a highly developed culture distinguished by an aristocratic government, great artistry in bronze, a writing system still in use today, an agricultural economy, and large armies whose commanders rode in chariots. Bronze casting reached a state of perfection yet to be surpassed anywhere in the world. An immense store of data on Shang society has been derived from the inscriptions on ORACLE BONES and from the contents of royal tombs, revealing in prototype the features that have characterized Chinese culture through the centuries.

Shanghai [shang'-hy] Shanghai is the leading industrial and commercial city of China. Lying south of the



The commercial center of Shanghai, flanking the Wusong River, retains the Western structures of the former International Settlement.

mouth of the Chang Jiang (Yangtze River), it is one of the world's great ports; about half of China's foreign commerce passes through the city. The city has a population of 7,330,000 (1989 est.) and a metropolitan-area population of 13,341,896 (1990).

Contemporary City. Like Beijing and Tianjin, Shanghai is administered directly by the central government. For administrative purposes the city—enlarged in 1958 to promote internal self-sufficiency in food production—is divided into ten urban districts. It now produces a wide variety of food crops, as well as livestock. The district formerly known as the International Settlement remains Western in appearance, with broad boulevards and tall, European-style buildings—a reminder of a time when the city had a permanent foreign population of 60,000.

Shanghai is a river port, lying at the confluence of the Huangpu and Wusong rivers, 24 km (15 mi) south of the Huangpu–Chang Jiang confluence. The Chang Jiang connects Shanghai to large areas of China's interior. The city also has an international airport; rail lines connect it to Nanjing and Hangzhou and, through these cities, to all China.

Shanghai has a wide range of commercial and manufacturing activities. Iron and steel, machinery, transportation equipment, and ships are among the heavy manufactured goods. Lighter industries turn out paper products, pharmaceuticals, precision instruments, textiles, and consumer goods. The city is also a printing and publishing center.

Shanghai has long been a center of culture and learning. Many of the institutions of higher learning within the city are major research centers. The Shanghai Library, Long Hua Temple, the Shanghai Industrial Exhibition, the Arts and Crafts Research Institute, the Shanghai Museum of Art, and the People's Opera House are there.

History. Shanghai's recorded history dates from before AD 900, but the city's rapid growth took place after the First OPIUM WAR (1839–42), when Shanghai became one of the ports opened to foreign trade by the Treaty of Nanjing. Because of its location at the mouth of China's busiest waterway and the commercial incentives and financial resources introduced by Western entrepreneurs, Shanghai had, by the turn of the 20th century, surpassed Guangzhou (Canton) as China's leading port. The many concessions to foreigners in Shanghai and the special political and economic privileges they enjoyed left the native inhabitants bitter and helped to radicalize them. The first major trade unions were organized in Shanghai (1919), as was the Communist party of China (1921).

Shangri-La [shan-gruh-lah'] *Shangri-La*, the name of the utopia in James HILTON's novel *Lost Horizon* (1933), now refers to any idyllic refuge. Hilton's Shangri-La, hidden in the mountains of Tibet, is a paradisiacal community of long life, refinement, unworldliness, and peace, whose values are diametrically opposed to those of modern society.

Shankar, Ravi [shahng'-kar, rah'-vee] The Indian musician and sitarist Ravi Shankar, b. Apr. 7, 1920, has been the major interpreter of INDIAN MUSIC to the West. As a child, he toured with the dance troupe of his brother Uday (1900–77), who popularized Hindu dance outside India. Ravi later turned to the study of the SITAR and in the 1950s began an ongoing series of tours in Europe and the United States. His scores for the *Pather Panchali* film trilogy (1954–59) attracted wide attention, as have his recordings and his performances with such Western classical musicians as Yehudi Menuhin.

Shankara see VEDANTA

Shannon, Claude Elwood [shan'-uhn] The American applied mathematician Claude Elwood Shannon, b. Gaylord, Mich., Apr. 30, 1916, developed (1948) a mathematical theory of communication that was later called INFORMATION THEORY. He defined *information* as the degree of freedom the information source has in choosing among elements of a language in order to compose a given message. This work, of fundamental importance in problems of COMMUNICATION, opened new paths of research in mathematics.

Shannon, River The River Shannon, the longest river in Ireland, drains about 15,700 km^2 (6,060 mi^2) in north central and western Ireland. The river rises in County Cavan and then flows south for 386 km (240 mi) through marshes, bogs, and lakes to Limerick, which lies at the head of the Shannon estuary on the Atlantic Ocean. Linked by canals to other rivers, the Shannon provides hydroelectric power and is a source of salmon and trout.

Shansi see SHANXI

Shantung see SHANDONG

shanty Shanties, or chanties (possibly from the French: *chanter*, "to sing"), were the work songs of English-speaking merchant seamen, who sang them while hauling ropes or performing other tasks requiring concerted effort. The refrains were sung by the sailors in unison, but the verses were typically assigned to a shantyman who stood apart and was excused from much of the heavy labor. A good shantyman, able to improvise songs fitted to the chore at hand, was greatly valued.

With the passing of the great sailing ships, shanties became of interest to collectors, often people with no ties to the sea. Among the best-known shanties are "Shenandoah," "The Rio Grande," and "Blow the Man Down."

Shanxi (Shansi) [shahn-see] Shanxi is a province in northeastern China covering an area of 157,100 km^2 (60,700 mi^2). It has a population of 28,759,014 (1982). TIAYUAN is the largest city and capital. The province is dominated by a plateau lying about 300 m (1,000 ft) above sea level. Mountains surround the plateau. Major rivers are the HUANG HE, Fen He, Hutuo He, and Sanggan He. The economy is based on the mining of coal and iron ore. Grains, cotton, tobacco, peanuts, and fruits are cultivated. Buddhist cave sculptures are at YUNGANG in Shanxi.

Strategically located between China and Mongolia, Shanxi was ruled from the 7th to 14th centuries alternately by local leaders and Turkic and Mongol invaders. The Ming dynasty (1368–1644) brought stable Chinese rule. Japan held Shanxi during the Sino-Japanese War of 1937–45.

Shapiro, Karl [shuh-pir'-oh] American poet and critic Karl Jay Shapiro, b. Baltimore, Md., Nov. 10, 1913, has published more than a dozen volumes of poetry—including *V-letter and Other Poems* (1944), for which he won the Pulitzer Prize—and several volumes of criticism, notably *In Defense of Ignorance* (1960), an attack on the learned poetry of Ezra Pound and T. S. Eliot and on the NEW CRITICISM.

Shapiro's early poetry, such as "Elegy for a Dead Soldier" (1944) and "Auto Wreck" (1942), is formal. *The Bourgeois Poet* (1964), consisting mainly of prose poems, shows a new Shapiro revolting against formalism. His poetry since *Selected Poems* (1968) returns to the early formal style but with a wider grasp of experience. His best later poems include "Adult Bookstore" and "The Piano Tuner's Wife" from the collection *Adult Bookstore* (1976). His *New and Selected Poems, 1940–86* was published in 1987.

Shapur II, King of Persia Shapur II, AD 309–79, ninth SASSANIAN king of Persia (r. 309–79), greatly enhanced the power of the Persian empire. The son and successor of Hormuz II, Shapur on coming of age resolved to regain Persian territory lost by his predecessors. He subdued the central Asiatic Kushans and annexed their kingdom. From the Romans he took Amida (Diyarbakir) in 359 and won Armenia shortly before his death. Shapur also sent expeditions against the tribes of Arabia and built walls and forts in Mesopotamia to defend against their forays.

After the Roman emperor Constantine I converted to Christianity, Shapur began a 40-year persecution of the Christians. ZOROASTRIANISM became firmly established as the state religion, and society was organized into castes. Although the reigns of his immediate successors were weak, Shapur brought to the Sassanian Empire a stability that enabled it to endure until the Arab conquest of the 7th century.

Sharaku [shah'-rah-koo] Sharaku, an enigmatic Japanese printmaker, is known to have worked for a period of only 10 months, from May 1794 to February 1795, during which time he produced an estimated 100–200 prints. His principal subjects were actors of the Kabuki (popular) stage and sumo wrestlers, whom he depicted in biting portraits full of satirical wit. Some scholars have identified him as Saito Jurobei, a No actor in the service of the lord of Awa.

Sharia *Sharia*, an Arabic word meaning "path," is the name of the sacred law of ISLAM. Regulating their duties to God and their relations with man, its decrees apply to all Muslims. Unlike Christianity, Islam through the Sharia emphasizes orthopraxis, or proper conduct, more strongly than orthodoxy, or proper belief.

In theory the Sharia is the immutable and infallible expression of the divine will as revealed in the KORAN and the *sunna* (sayings and actions of the Prophet MUHAMMAD). In fact, the Sharia developed over the course of several centuries, incorporating laws derived from ancient Arabian custom as well as those of the peoples conquered during the first century of Islam. Many legal rulings formulated by jurists in response to actual cases were also included. By the 8th century a movement toward systematizing the Sharia had arisen, notably at Medina, where the first legal digest was produced by Malik ibn-Arias (d. 796).

The systematic interpretation of the law came to be called *fiqh* (knowledge). In order to interpret the law and to make it applicable to circumstances not mentioned in the Koran and *sunna*, the jurists introduced several categories of jurisprudence: *qiyas* (argument by analogy), *ijma* (argument from the consensus of the Muslim community), and *ijtihad* (independent argument in the absence of consensus). All activity was classified into five categories: the obligatory, the recommended, the permitted, the reprehensible, and the forbidden. Several *fiqh* schools developed differing mainly in the use of *qiyas*, *ijma*, and *ijtihad*. In the two major branches of Islam, Shiite schools of law differ substantially from the Sunnite ones only in their inheritance law, their rejection of *qiyas*, and their free use of *ijtihad*, which the Sunni schools strictly regulated from the 13th century on.

Since Abbasid times (AD 750), no attempt has been made to enforce the Sharia in its entirety. In some Muslim countries attempts have been undertaken to make the Sharia conform to Western legal notions. Even so, the Sharia has remained the model by which pious Muslims judge every legal system in Islamic countries.

shark Sharks are approximately 350 species of cartilaginous fishes that vary greatly size, behavior, and in the way they reproduce. They are found at all depths in all the oceans of the world except the Antarctic but are most abundant in tropical and subtropical waters. A few inhabit freshwater lakes and rivers, and some migrate regularly from salt to freshwater. Sharks are remarkably successful animals, with few parasites or diseases and almost no enemies except other sharks. As predators and scavengers, sharks play a major role in the ecosystems of the world's oceans.

Evolution. Sharks comprise the order Selachii; together with the skates and rays they constitute the subclass Elasmobranchii in the class CHONDRICHTHYES of cartilaginous fishes, which also includes the chimaeras. Paleontologists believe that such fishes evolved from primitive, heavily armored, sluggish fishes called placoderms, which became extinct about 350 million years ago at the end of the Devonian, the period in which the first sharklike fishes appeared. Although they retain many primitive features, sharks since then have continued to evolve; they now occupy a wide range of ecological niches. They also exhibit a fairly rapid learning ability, despite being considered less advanced than the bony fishes.

Characteristics. Most sharks are easily identified by distinctive characteristics such as a ventrally positioned mouth, (usually) five gill slits, an asymmetrical tail with the vertebral column extending into the upper lobe, and a body covered with tiny, sharply pointed placoid scales. Some species, however, exhibit notable variations of these characteristics. Male sharks are distinguished by the presence of claspers: extensions of the pelvic fins that serve as copulatory organs. Most sharks swim constantly but leisurely, propelled by the sculling motion of the body and tail, but many are capable of sudden bursts of speed.

Internally, sharks differ from the bony fishes in having cartilaginous skeletons, skulls without sutures, and reserve rows of teeth attached to (and in fact part of) the skin of the jaws. These rows roll outward, providing a continual supply of teeth to replace those which are lost. Sharks also lack an air bladder, forcing all but shallow-water forms to swim constantly in order to keep from sinking. Sharks have a specialized type of intestine called a spiral valve, which increases the secretory and absorptive surfaces considerably. An epithelial fold spirals the length of the small intestine.

One of the most important reasons for the success of sharks is their well-developed sensory system. Their eyes are highly sensitive to contrasts of light and shadow and are especially adapted to see in dim light. Their sense of smell is extraordinarily acute, and their lateral-line system, which alerts fish to vibrations of low frequency in the water (see FISH), is large and well developed. The so-called ampullae of Lorenzini on a shark's snout are sensitive to weak electrical stimuli produced by muscle contractions of bony fish, and sensory pit organs exist elsewhere on the body.

The largest shark—and the largest fish in the sea—is the whale shark, *Rhinocodon typus*, which grows to 15 m (49 ft) or longer. Like the basking shark, *Cetorhinus maximus*—at approximately 10 m (33 ft), the second largest shark—it feeds solely on plankton and small fish. The largest predatory shark is the great white, *Charcharodon carcharias*, which is usually full grown at lengths of about 6 m (20 ft). The smallest shark, the cigar shark, *Squaliolus laticaudus*, is only 15 to 20 cm (6 to 8 in) long at maturity.

Some sharks dwell in very deep waters and are only rarely observed; a number of them are bioluminescent and brightly colored. At least one deep-water species has in fact become known only from fragments of dead specimens.

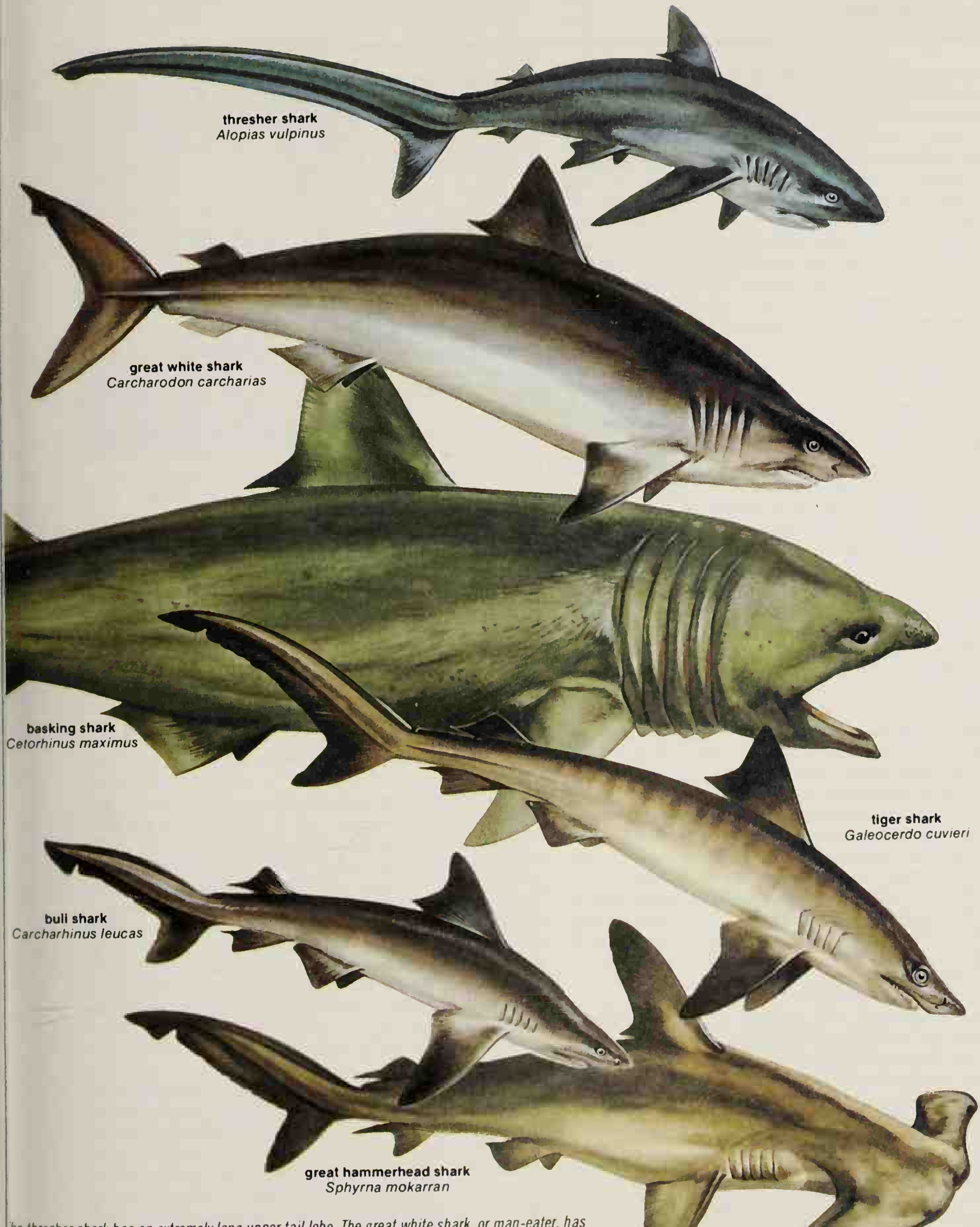
Behavior Patterns. Some sharks, such as the great white, are loners and seemingly swim at random, although they sometimes gather to feed. Some gather in schools, and others school only for migrations either horizontally (north, south, east, west) or vertically (to deeper, cooler waters). A migration may be but a brief trek shoreward or may last for thousands of kilometers. Enormous congregations of spiny dogfish, Squalidae, which are small sharks about 1 m (3.3 ft) long, migrate annually in the western Atlantic from the Caribbean to sub-Arctic waters.

Sharks exhibit three different forms of reproduction. Some species lay eggs encased in leathery shells, usually with tendrils that anchor them to rocks or vegetation (oviparous); some have eggs that develop within the females' uteri, and the young are born alive (ovoviviparous); and some have a method similar to that in mammals, in which the young develop *in utero* and are nourished by maternal blood delivered through an umbilical stalk from a placenta (viviparous).

In all sharks fertilization of the eggs occurs internally. During copulation only one clasper has been observed to be inserted into the female. Gestation varies from a few months to more than 2 years. The longest known gestation period of any vertebrate, 20–24 months, is that of the spiny dogfish.

Unlike the bony fishes, which usually lay enormous numbers of tiny eggs that develop into minute young, sharks produce small numbers of large young. The largest litter contains less than 100 young, whereas the usual litter is far smaller. Some species such as the sand tiger produce only 2 young.

At birth all sharks are completely developed; there is no parental care. Their diet includes nearly every animal in the sea, including their own kind. Although their voracity is legendary, they also fast for long periods, when they subsist on the oil in their livers. In contrast, sharks also indulge in eating orgies known as "feeding frenzies." Large numbers of sharks attracted to the same bait be-



he thresher shark has an extremely long upper tail lobe. The great white shark, or man-eater, has een credited with most of the shark attacks on humans. The basking shark may exceed 12 m (40 t) in length and weigh up to 5 tons. The tiger shark is known for its voracious and indiscriminate eeding habits. The bull shark, found in warm coastal waters, may migrate into rivers in search of ood. A flattened, laterally extended head distinguishes the hammerhead shark.

come a whirling circle of activity, with jaws ripping not only into the food source but also into each other.

Sharks and Humans. Well attuned to most of the waters of the world, sharks appear to dominate the depths. Swimmers, water skiers, snorkelers, scuba divers, and spear fishers in ever-increasing numbers are invading their habitats, however, and sharks have responded to the intrusion with predictable reflex reactions—they have occasionally attacked. The resulting notoriety has given sharks a bad reputation that is not reinforced by the facts. Of the 100 or so unprovoked attacks that occur worldwide every year, less than 35 are fatal. Only about 30 species are considered dangerous to humans, with just 5 species implicated most often in attacks: great white sharks; tiger sharks, *Galeocerdo cuvieri*; hammerheads, *Sphyrna*; bull sharks, *Carcharhinus leucas*; and the oceanic whitetip sharks, *C. longimanus*. Any sharks seen in the water, however, should be treated with caution.

Although sharks play a positive ecological role, their predacious activity has led many fishers to consider them undesirable animals. In fact, the flesh of some sharks is an excellent food and is eaten extensively. Potentially, sharks are a rich but rarely harvested source of food, oil, vitamins, fertilizer, leather, and curios.

Sharon, Ariel [shah-rohn'] Ariel Sharon, b. Palestine, 1928, is one of Israel's most controversial military and political figures. He joined the Haganah (Jewish militia) as a youth and became one of the Israeli army's most flamboyant commanders, playing a significant role in each of the ARAB-ISRAELI WARS. An outspoken opponent of territorial concessions to Arabs, he resigned from the army in 1973 to enter politics and helped found the Likud coalition. Under Menachem BEGIN, Sharon expanded Jewish settlement in the Israeli-occupied territories as minister of agriculture in charge of settlements (1977–81) and was forced to resign (1983) as minister of defense over his role in the 1982 Israeli invasion of Lebanon. Named minister of trade and industry by Yitzhak SHAMIR after losing a bid for Likud leadership in 1984, his resignation in February 1990 helped bring down the government. In June he became minister of housing.

Sharon, Plain of The Plain of Sharon is a fertile Mediterranean coastal strip about 16 km (10 mi) wide and 90 km (55 mi) long between Tel Aviv-Jaffa and Haifa, Israel. Burial urns from the 4th millennium BC have been found there, and the plain was often mentioned in the Old Testament. After the forests were cut in the 19th century, it became semiarid, but economic recovery came in the 20th century with citrus farming and extensive urbanization, industrialization, and tourism.

Shasta, Mount [shas'-tuh] Mount Shasta, a 4,317-m-high (14,162-ft) dormant volcano, is located in the southern CASCADE RANGE of northern California. The peak is 3,000 m (10,000 ft) above the base, and five glaciers cover much of the area above the timberline. In addition to the main peak a secondary cone crests at 3,790 m (12,433 ft) on the western slope. Although no eruptions have been recorded, hot springs occur.

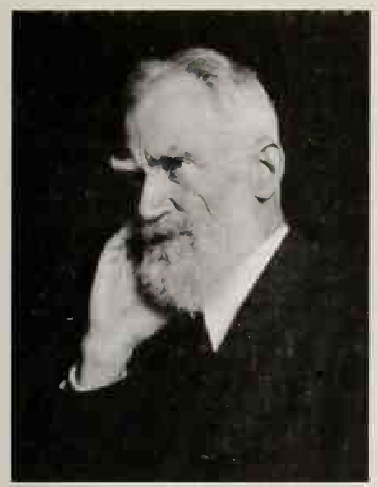
Shatt-al-Arab [shaht-ahl-ah'-rahb] The Shatt-al-Arab (meaning "river of the Arabs" in Arabic) is a 193-km-long (120-mi) river in Iraq, formed by the confluence of the TIGRIS and EUPHRATES rivers at Al-Qurna. The river flows southeast along the Iran-Iraq boundary into the Persian Gulf. Its waters are used for irrigation; ocean steamers can go as far north as BASRA, although navigation is difficult above ABADAN. A 1975 agreement between Iran and Iraq, reaffirmed in 1990, after Iraq's invasion of Kuwait, defined the middle of the Shatt-al-Arab as the Iran-Iraq border. Iraq launched the IRAN-IRAQ WAR (1980–88) to establish its sovereignty over the entire waterway, including three islands at its mouth occupied by Iran in 1971. The war halted all shipping on the Shatt-al-Arab. Iraq's main port at Basra was closed, and a huge Iranian petroleum refinery on an island in the delta at Abadan was destroyed.

Shavuoth [shuh-vu'-uht] One of the three Jewish pilgrim festivals, Shavuoth, also called the Feast of Weeks, or PENTECOST, is observed 7 weeks after the first day of PASSOVER. Originally an agricultural festival, it was a celebration of the first fruits of the wheat harvest. Beginning on the 6th day of Sivan, Shavuoth came to be associated with the giving of the Law to Moses.

Shaw, Anna Howard Anna Howard Shaw, b. England, Feb. 14, 1847, d. July 2, 1919, was a leader of the American women's suffrage and temperance movements. Having emigrated as a child, she earned U.S. degrees in theology and medicine and became the first woman ordained (1880) by the Methodist Protestant church. Shaw left the pulpit in 1885 to work for women's suffrage. An eloquent orator, she served (1888–92) as national superintendent of the Franchise Department for the Women's Christian Temperance Union (WCTU) and as president (1904–15) of the National American Woman Suffrage Association.

Shaw, George Bernard Besides writing some of the finest plays of the 20th century, George Bernard Shaw, or "G.B.S." as he came to be known (or Bernard Shaw, as he preferred to be known), b. Dublin, July 26, 1856, d. Nov. 2, 1950, was one of the most influential music and drama critics of his time, a superb essayist, and a penetrating analyst of virtually every important aspect of Western culture. He even left behind an adjective, *Shavian*, used to describe anything resembling his distinctive ideas or personality.

Shaw's father was an unsuccessful merchant who took



Bernard Shaw, author of more than 60 plays, was also a distinguished essayist and music critic. With a masterful, often trenchant prose style, Shaw ignored the typical academic jargon of the day to make music accessible to more people. He championed such composers as Wagner, Elgar, and Mozart.

to drink (which was why Shaw himself abstained), and his mother was an accomplished concert singer. The Shaws were what G.B.S. called downstarts—down from upper-middle-class affluence into genteel poverty. Still, Mrs. Shaw had enough money to support her grown son when he decided to follow her to London in 1876 and write such novels as *The Irrational Knot* (1879), *Love among the Artists* (1881), *Cashel Byron's Profession* (1882), and *An Unsocial Socialist* (1884), all published in socialist journals.

Early Plays. Although the novels were ignored by both critics and the public, Shaw had begun to reach an audience through his magazine articles—reviewing books for the *Pall Mall Gazette*, art for the *World*, and music for the *Star*. His first play, *Widowers' Houses*, begun in 1885, was not produced until 1892, but it was followed in rapid succession by *The Philanderer* (1893), *Mrs. Warren's Profession* (1893), *Arms and the Man (1894), Candida (1895)*, and *You Never Can Tell* (1896)—all six published together in 1898 as *Plays Pleasant and Unpleasant*. Because plays were hitherto not regarded as publishable items, Shaw resolved to make them so by adding readable, novelistic stage directions and what would become his trademark—the long prefatory essay. (In 1898, Shaw also began his marriage to Charlotte Payne-Townshend, which was generally a happy one despite his many, though mostly epistolary, love affairs, notably those with Ellen TERRY and Mrs. Patrick CAMPBELL, for both of whom he wrote plays.)

Shaw's next volume, *Three Plays for Puritans* (1901), included *The Devil's Disciple* (1897), *Caesar and Cleopatra* (1899), and *Captain Brassbound's Conversion* (1900). Next he planned to write "Plays of Science and Religion," but instead the individual plays—*Man and Superman*, (1903), *John Bull's Other Island* (1904), and *Major Barbara (1905)*—appeared separately because of the extreme length of *Man and Superman*, actually two plays in one: an inverted comedy of manners and the "Don Juan in Hell" discussion play. Shaw's works became firmly established in the London theater under the direction of Harley GRANVILLE-BARKER, particularly during 1904–07 at the Court Theatre. Shaw's most successful play, PYGMALION, was published in 1914.

Later Works. At the age of 60, in the middle of World War I, Shaw completed a play that represented a new departure in his dramatic art and is regarded by some as his masterpiece—*Heartbreak House* (1916), a theatrical image of the collapse of civilization. World War I had brought a sense of the possible destruction of the Earth and visions of some Phoenix-like world that would rise in flame from the ruins. Such a fantasy is developed in Shaw's longest and most ambitious play, *Back to Methuselah* (1920). *Saint Joan*, which followed the canonization (1920) of Joan of Arc by three years, is romance, tragedy, and comedy combined to form another masterwork.

Although Shaw won the Nobel Prize for literature in 1925 and went on writing plays almost until his death at the age of 94, none of the later works enjoyed wide success. Of particular interest is his experimentation with Aristophanic extravaganza in which contemporary political figures appear in bizarre but meaningful disguises. The contemporary politicians Asquith and Lloyd George suggested characters in *Back to Methuselah*, and in *Geneva* (1938) Shaw put Hitler, Mussolini, and Franco onto his comic stage.

Thought. As a youth, Shaw rejected orthodoxy to become an atheist and a Darwinist. He found these positions too negative, however, and in search of affirmations he made his way through radical anarchism and Marxism to socialism, where he had arrived in 1883 when he became a founding member of the FABIAN SOCIETY. Although he never abandoned socialism, Shaw found it insufficient, and his next quest ended in what he called creative evolution, which viewed life as a whole and over an infinite time span.

World War I changed Shaw's mind on certain important points. He replaced any lingering faith he may have had in liberal democracy with a firm trust in the resources of Russian Communism. He admired strong men who used force to bring about change, and he had friendly words for Stalin and even Mussolini. Consistency was not his forte, however, and one must remember Shaw's characteristic propensity to exaggerate and clown in order to attract attention to himself and his ideas and works.

Shaw, Irwin An American novelist whose works explore contemporary political and social themes, Irwin Shaw, b. Brooklyn, N.Y., Feb. 27, 1913, d. May 16, 1984, was critically acclaimed for his first novel, *The Young Lions* (1948; film, 1958), which questions the moral attitudes of Americans at war, and for his early short stories, collected with others in *Short Stories: Five Decades* (1978). Other novels include *The Troubled Air* (1951), *Rich Man, Poor Man* (1970), *Beggarman, Thief* (1977), *Top of the Hill* (1979), *Bread upon the Waters* (1981), and *Acceptable Losses* (1982).

shawm The earliest European form of the OBOE, the shawm was probably brought from the East in the 12th century. By the 1500s the complete family of shawms ranged from high soprano to low bass instruments, the latter called bombards. The shawm consisted of a conically bored wooden tube with seven finger holes, played with a double reed. Supplanted by the modern oboes in the 1600s, shawms have recently reappeared in ensembles that perform early music.

Shawn, Ted Edwin Myers "Ted" Shawn, b. Kansas City, Mo., Oct. 21, 1891, d. Jan. 9, 1972, as performer, choreographer, producer, author, and teacher, helped to establish dance in the United States (see MODERN DANCE). Shawn envisioned an American dance art drawn from dances of native Americans and immigrant cultures that were part of American society. With his wife, Ruth ST. DENIS, Shawn established the DENISHAWN company and school. From 1933 to 1940 he toured with his troupe of Men Dancers, presenting dances filled with virile movements derived from primitive dancing, labor, and sports and establishing dancing as a respectable profession for men. Shawn also directed a summer dance festival (1941–72) and school (1933–72) at JACOB'S PILLOW, Mass.

Shawnee [shaw-nee'] The Shawnee ("southerners") are a North American Indian tribe of the Algonquian-Wakashan linguistic stock who had moved from the upper Ohio valley to territory around the Cumberland River in present-day Kentucky and Tennessee by the mid-17th century. At that time they numbered an estimated 1,500. Their five divisions moved frequently.

In later years the Shawnee lived on the Scioto, Miami, and Auglaize rivers (Ohio); in 1798 they settled on the White River (Indiana). They lay directly in the path of American westward expansion. In 1805, Tenskwatawa, the Shawnee Prophet, began to preach Pan-Indianism and peace, and his twin brother, TECUMSEH, carried these revelations to the tribes. The fighting over U.S. advances west continued, however, and the Indians were crushed at the Battle of TIPPECANOE by U.S. forces led by Gen. William Henry HARRISON on Nov. 7, 1811. In the 1820s the Shawnee lived in Ohio, Missouri, Kansas, and Texas. In 1845 the Hathawekela, Kispokotha, and Piqua moved from Kansas to the Canadian River, Okla., and became known as the Absentee Shawnee. By 1870 many Shawnee had been incorporated into the CHEROKEE nation. Today the Shawnee living on or near reservations in Oklahoma number approximately 1,385 (1989 est.).

Shawnee Prophet The Shawnee Prophet, Tenskwatawa ("the open door"), b. 1768, d. 1837, twin brother of the warrior TECUMSEH, was the mystic leader of an early Pan-Indian movement. In a trance he had seen the past, the present, and the future and had visited the spirit world. In 1805 he told his revelations to the assembled tribespeople: they must return to their old ways, cease to intermarry with whites, stop drinking, respect the aged and infirm, refuse to sell their land, live in peace, and listen to the Master of Life. He and Tecumseh planned an uprising of all tribes, by which the white men would be driven from the land. Tenskwatawa's prestige increased when he correctly predicted an eclipse of the Sun in 1806. In 1811, Tecumseh, leaving Tenskwatawa in the North with orders not to be provoked into battle with U.S. forces, journeyed south to carry the Prophet's call for an uprising to the CREEK and other southern tribes. The Prophet, however, disobeyed orders and was totally defeated by the Americans near Tippecanoe Creek (see TIPPECANOE, BATTLE OF), Nov. 7, 1811. He lived in Canada as a British pensioner until 1826. In 1828 he moved to Kansas, where George CATLIN painted his portrait.

Shays's Rebellion [shayz] Shays's Rebellion was an armed outbreak by debtor farmers in western Massachusetts in 1786–87. Directed against the courts, the uprising followed years of fruitless appeals for relief from an unsympathetic state government. By alarming conservatives in Massachusetts and the other states, it spurred the drive for a strong national government.

During the 1780s the merchant-dominated Massachusetts government imposed heavy taxes to retire state debts, while rejecting paper money and stay laws for debtor relief. As a result, seizure of debtor farmers' property and imprisonment for debt became common. In August 1786, armed mobs began closing courts in western counties, and soon Revolutionary War veteran Daniel Shays (*c.*1747–1825) became the insurgents' leader. The state militia dispersed rebels in Springfield on Jan. 25, 1787. On February 4 the Shaysites were dealt a crushing blow at Petersham.

The state government initially imposed harsh sentences on rebels. A more liberal government was elected in 1787, however; it soon offered full pardon to all, including Shays and other leaders. Some modest relief for debtors was provided.

shearwater Shearwaters are any of several large (38–64 cm/15–25 in), gull-like oceanic birds in the family Procellaridae, related to the petrels and the fulmars. They have long, narrow, pointed wings, and they fly so low over water when feeding that they seem to shear the surface. Shearwaters are migratory and are found over the world's oceans, coming to land only to breed. Most species are white, gray, brown, black, or a combination of these colors. They have slender, hooked bills, tubed nostrils, and webbed feet. The sooty shearwater, *Puffinus griseus*, at times common to the eastern coast of the United States, is one of several species that breed in the Southern Hemisphere and move across the equator to winter. Shearwaters nest in large colonies, usually in burrows, which are dug by both parents, or in rock crevices.

sheathbill The snowy sheathbill, *Chionis alba*, and the lesser sheathbill, *C. minor*, are the only members of the bird family Chionididae. They inhabit the southern tip of South America and various oceanic islands in the far south Atlantic and Indian oceans and are the only birds to reach Antarctica that have unwebbed feet. They measure 38–42 cm (16–17 in) in length and have completely white plumage. Their name is derived from a horny sheath over the base of the bill. A patch of bare, wattled skin lies in the cheek area, and the bill is short. The wings are long and have spurs used for intraspecies fighting; the tail and legs are short. Sheathbills often seem reluctant to take wing but can make long overwater flights. They are scavengers and frequent seacoasts to steal such food as small fish, crustaceans, and mollusks from other birds as well as to search for algae, refuse, and carrion. Their nests are built in rock crevices or old burrows.

Sheba [shee'-buh] Sheba is the Hebrew spelling of Saba, an ancient Arabian kingdom roughly corresponding to modern Yemen. Linguistic and archaeological evidence suggests that Sheba was originally settled by Semites from western or central Arabia during the 2d millennium BC and that by about 1200 the Sabeans were trading with the northern zones of Arabia, Palestine, and Syria. Thereafter, Sheba formed a vital southern terminus for trade routes originating as far north as Mesopotamia; during the 1st millennium BC it dominated Red Sea and Indian Ocean trade.

Excavations at Ma'rib, its capital, have revealed an imposing temple to the moon-god and a great dam indicating highly developed engineering skills. Sheba is best known, however, for the biblical visit of the Queen of Sheba to Jerusalem in the time (10th century BC) of Israel's King SOLOMON (Kings 10:1–13).

Sheboygan [shuh-boy'-guhn] Sheboygan (1990 pop., 49,676), a city situated in eastern Wisconsin about 90 km (55 mi) north of Milwaukee, is a port on Lake Michigan and the seat of Sheboygan County. Now an industrial center producing enamelware, wood products, sausage, and cheese, the city was established around a sawmill in 1835. Many Germans settled there during the 1840s and '50s.

Sheeler, Charles [shee'-lur] The American painter Charles Sheeler, b. Philadelphia, July 16, 1883, d. May 7, 1965, is known for his sleek, simplified depictions of the industrial landscape; these, produced after 1917, reflect a version of cubism emphasizing precise, careful draftsmanship and relatively cool, flat colors. First influenced by the intense color and loaded brushstrokes of the Fauves, Sheeler exhibited in the New York Armory Show of 1913. His later style, however, consisted of a meticulous approach that involved less distortion than conventional cubism. Instead, Sheeler's barns, buildings, towers, and factories are simplified and subtly reorganized to stress the interrelationships among their abstract shapes, such as *American Landscape* (1930; Museum of Modern Art, New York City). Sheeler, along with Charles Demuth, belonged to a group variously called the "cubist-realists," "immaculates," and "precisionists."

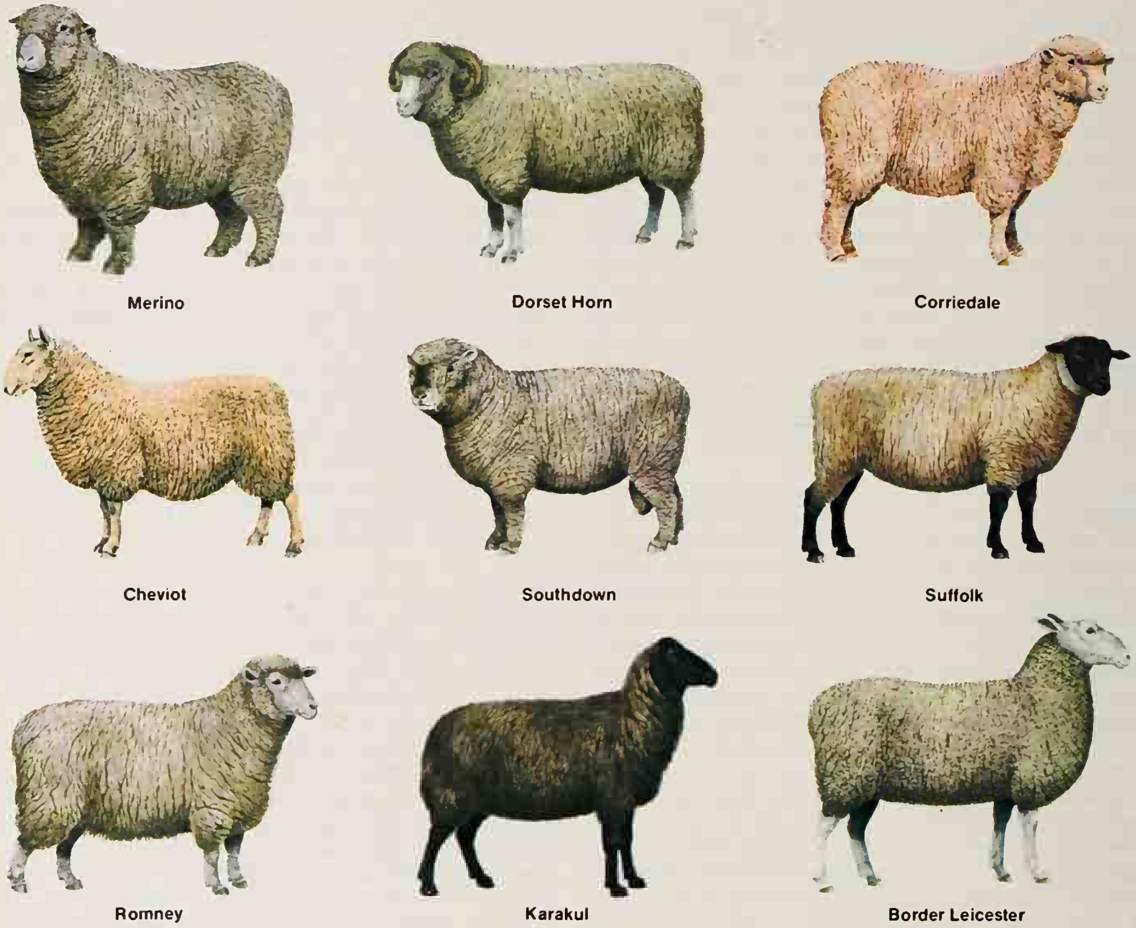
Sheen, Fulton J. [sheen] Best known for popularizing religion through television and radio programs, Archbishop Fulton John Sheen, b. El Paso, Ill., May 8, 1895, d. Dec. 9, 1979, was long considered one of the most brilliant and persuasive members of the American Roman Catholic hierarchy. From 1927 to 1950 he served as a philosophy professor at the Catholic University of America, Washington, D.C. Along with his scholarly studies, Sheen wrote many popular works, among them *Walk with God* (1965) and *The Moral Universe* (1967). His television series, "Life Is Worth Living," was a top-rated program in the early 1950s. Sheen was consecrated auxiliary bishop of New York in 1951 and was named to head the Rochester, N.Y., diocese in 1966. He resigned in 1969.

sheep Sheep are hollow-horned ruminants of the genus *Ovis*, suborder Ruminata, family Bovidae. Similar to goats, sheep differ in their stockier bodies, the presence of scent glands in face and hind feet, and the absence of beards in the males. Domesticated sheep are also more timid and prefer to flock and follow a leader. Large wild sheep with spiral horns occur in several areas of the world. One of these is the argali, *O. ammon*, found in the Altai Mountains. Other similar types occur throughout Central Asia. The Rocky Mountain bighorn, *O. canadensis*, occurs at higher elevations from Mexico to Alaska. These sheep are typically a brownish tan color, but color ranges from the almost white Dall sheep of Alaska, *O. dalli*, to an almost black race in British Columbia. Wild sheep similar to those in North America also occur in Siberia and Kamchatka. A small, hairy wild sheep of Corsica and Sardinia, the mouflon, *O. musimon*, resembles the Asiatic mouflon, *O. orientalis*. A third small wild sheep, the urial, *O. vignei*, occurs in Afghanistan and the Punjab.

Domestic sheep, *O. aries*, were derived mainly from the mouflon, and domestication occurred about 10,000 BC. As early as 2000 BC both wool and mutton types were kept. Selective breeding was practiced by the Romans, who began sheep husbandry in Spain and Britain. Land enclosure encouraged controlled breeding and the gradual development of improved breeds. Approximately 300 domesticated breeds now exist, but only a few are extensively raised. Sheep are bred on all continents and in all climates. They are raised chiefly for meat and wool. Lamb pelts of the Karakul sheep are sold as a fur called Persian lamb. Cheese made from sheep's milk is a popular food in many countries.

The major sheep-raising countries are the USSR, Australia, China, New Zealand, Turkey, India, and Argentina.

Principal Sheep Breeds. Wool is the main commercial



Merino

Dorset Horn

Corriedale

Cheviot

Southdown

Suffolk

Romney

Karakul

Border Leicester

Domestic sheep, bred for wool, meat, and milk, are classified by wool type. The Merino is a fine-wool breed, raised for its fleece. Medium-wool breeds include the white-faced Dorset Horn, Corriedale, and Cheviot, all of which provide both meat and wool; the dark-faced Southdown and Suffolk are bred for mutton but provide wool of acceptable quality. The Romney is a long-wool breed raised mostly for mutton. The Karakul is a fur-bearing breed; young lambs are the source of Persian lamb pelts. New breeds are sometimes developed according to economic needs in different local environments. The Border Leicester, a cross between the Leicester and Cheviot, was bred primarily for mutton.

product of the sheep industry, and specialized sheep breeds are usually classified according to wool type. The fine-wool breeds are typified by the Merino and Rambouillet, which originated, respectively, in Spain and France. The fleece of these breeds is noted for small fibers, large numbers of crimps per inch, and high oil content. Sheared fleece is called "grease wool"; washing removes the oil, lanolin, which is widely used in cosmetics manufacture.

Medium-wool breeds produce fleeces that are medium in length, fineness, and weight. Important medium-wool white-face breeds in the United States are Cheviot, Columbia, Corriedale, Dorset, Montadale, Panama, Romeldale, and Targhee. Principal medium-wool dark-face breeds are the Hampshire, Oxford, Shropshire, Southdown, and Suffolk. These breeds are also noted for their mutton qualities.

Long-wool breeds produce fleeces with long fibers (13–30 cm/5–12 in) and less crimp. The principal U.S. long-wool breeds are the Leicester, Cotswold, Lincoln, and Romney.

The U.S. Sheep Industry. The leading sheep-raising states are Texas, Wyoming, California, South Dakota, Idaho, and New Mexico. In the western states, the industry is a range enterprise oriented toward wool production. Large flocks of 1,000 or more sheep are grazed together on the range. They are kept penned only for winter feeding and spring lambing seasons. In contrast, the small farm flocks of the corn-belt and eastern states are usually supplementary enterprises oriented toward the production of spring lambs.

See also: ANIMAL HUSBANDRY; BIGHORN; MOUNTAIN SHEEP.

sheep, mountain see MOUNTAIN SHEEP

sheet-fed press A sheet-fed press is a printing machine into which paper is fed one sheet at a time, as opposed to a web-fed press, into which paper is fed from a reel. Sheet-fed presses may be platen, flat-bed cylinder or rotary machines; they print by any process. Each sheet to be printed must be accurately positioned so that the image will appear in the same place on every sheet. Accuracy is achieved by feeding sheets to three points of contact, or lays: two on the long edge of the sheet—the front lays—and a third on the short edge—the side lay. In early PRINTING machines the sheets were fed to the lays by hand, but as speeds increased it became necessary to develop automatic sheet feeders. These use an air blast to separate sheets in a stack, with vacuum suckers to pick up one sheet at a time and convey it forward for printing. Some sheet feeders have suckers picking up at the front edge and feeding each sheet forward to the lays, others pick up at the back edge and feed the sheets forward in a continuous underlapped stream. All sheet-fed presses with automatic feeders must incorporate devices to detect double sheets, missed sheets, misregister, or buckled paper. Automatic feeders today are capable of feeding sheet-fed presses up to 10,000 sheets per hour, compared with hand feeding of about 2,000 sheets per hour.

Sheffield [shef'-eeld] Sheffield, the largest city in South Yorkshire, England, with a population of 528,300 (1988 est.), lies about 225 km (140 mi) northwest of London. Steel, copper, brass, processed foods, and textiles are manufactured. The city has a university (1905) and a 12th-century church and castle.

Sheffield was established by the early 12th century. Since at least the 14th century, it has been noted for its cutlery industry; smiths and cutlers use the local grit stone for grinding. In 1742, Thomas Boulsover invented Sheffield plate, a method for fusing silver on copper. After Henry Bessemer developed a new process for making steel there in 1856 and after the arrival of the railroad in 1876, the city became a center for heavy industry.

Shelburne, William Petty Fitzmaurice, 2d Earl of [shel'-burn] William Petty Fitzmaurice, 2d earl of Shelburne and 1st marquess of Lansdowne, b. May 20, 1737, d. May 7, 1805, British prime minister (1782–83), negotiated the 1783 Treaty of Paris, which recognized American independence. Minister for the colonies (1766–68), he resigned from the ministry of William Pitt the Elder in part because he wished to conciliate the American colonists. Lord Shelburne joined the Whig ministry of Lord ROCKINGHAM in 1782 and, on Rockingham's death, was chosen by George III to form a government, but disagreement with Charles James Fox and with the so-called Rockingham Whigs compelled his resignation.

Shelby, Isaac [shel'-bee] Isaac Shelby, b. Washington County, Md., Dec. 11, 1750, d. July 18, 1826, was an American frontier soldier and the first governor of Kentucky. During the American Revolution he led (1780–81) frontier soldiers against British forces in the Carolinas. Shelby moved from North Carolina to Kentucky *c.*1783 and participated in the process that led to statehood in 1792. He won 4-year terms as governor in 1792 and 1812. In the War of 1812, 4,000 Kentucky volunteers organized and led by Shelby won the Battle of the Thames (Oct. 15, 1813).

shell Shells of various animals—invertebrates such as brachiopods, mollusks, and crustaceans, and vertebrates such as turtles (and of the eggs of amphibians, reptiles, and birds)—serve to protect and support soft body tissue. The term *shell* is also used to describe the hard outer covering of various nuts and seeds of plants.

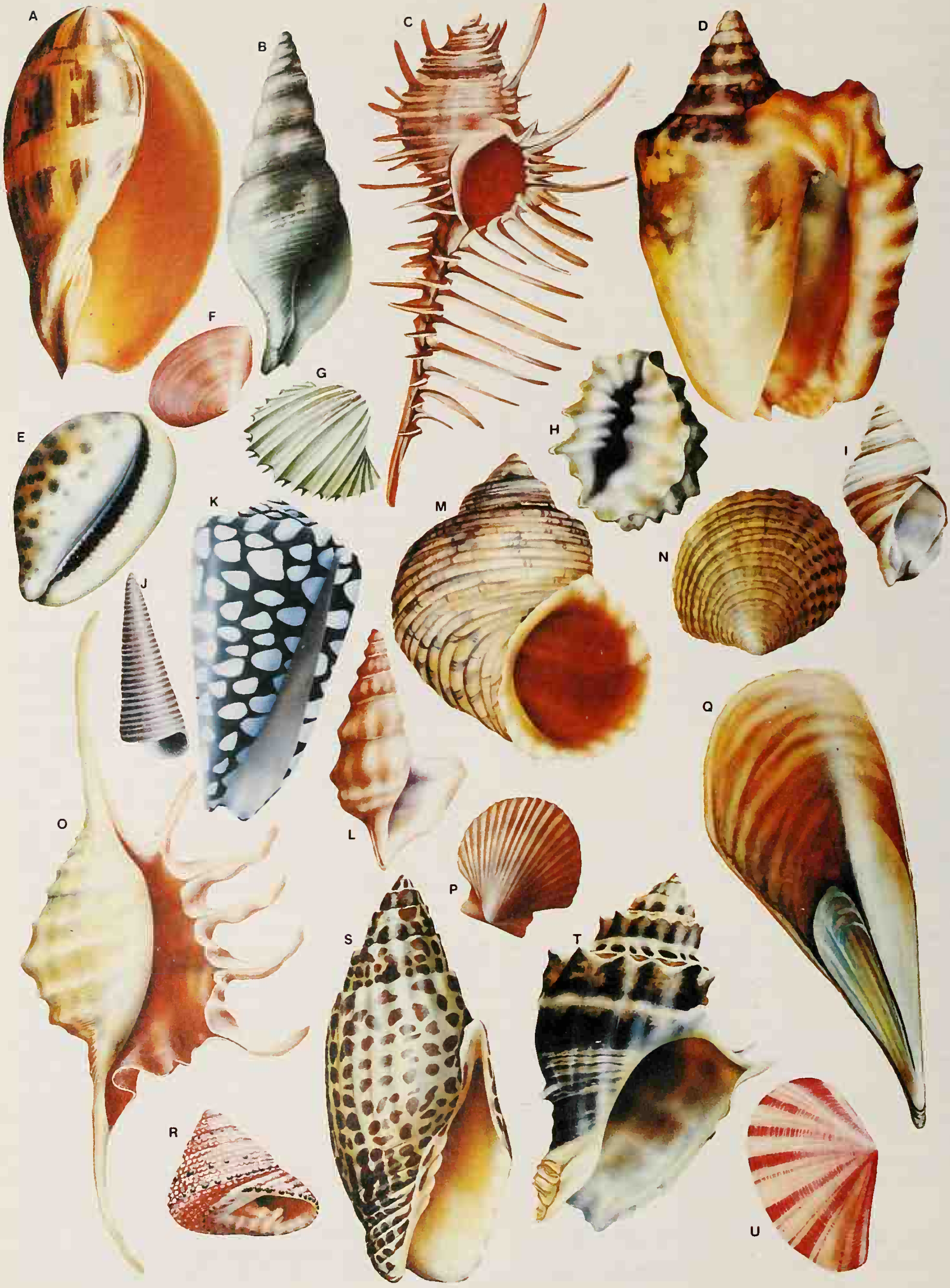
Generally, invertebrate shells are calciferous secretions, although those of certain protozoan species are composed of cellulose, chitin, tectin, or siliceous material. The soft mantle tissue of BRACHIOPODS, or lamp shells, secretes a shell containing chitin and calcium carbonate, which grows as the animal grows. ECHINODERMS, including sea urchins, starfish, and sand dollars, have shells that are embedded inside the soft body tissue and also become larger as the animal grows. This type of shell consists of a complex network of calcium carbonate, the spaces of which are filled with living cells. When the animal dies, the shape and form of the body are retained.

Many CRUSTACEANS—notably barnacles, lobsters, and crabs—grow and shed several shells within a short period of time. Crustacean shells generally contain chitin, which is a hardened network of polysaccharide molecules, calcium carbonate, and phosphate.

Almost all mollusks have shells, exceptions being the nudibranch, a marine animal, and the garden slug. (Some mollusks, such as squids and sea hares, have internal shell plates, and a few possess shells only during the larval or juvenile stages and subsequently shed them in their adult form.) The mollusk shell consists of a calciferous liquid that is secreted by the soft mantle tissue and then hardens. The shell has three layers: an inner, shiny layer of nacre, or mother-of-pearl, which is a mixture of calcium carbonate and a protein known as conchiolin; a central, prismatic layer of calcium carbonate crystals; and an outer, organic layer made of conchiolin.

The shell of a chiton, or coat-of-mail shell, consists of eight linked plates. In all other shelled mollusks, however, the shell is composed of one or two parts. In gastropods, the single shell ranges from extremely fragile and transparent, as in some snails, to heavy and massive, as in larger conchs. A scaphopod, or tusk shell, has a single shell in the form of a tapering cylinder with an opening at both ends. Bivalves have a pair of attached shells, or valves, which may be equal in size and shape, as in clams, or unequal, as in scallops. The bivalve shells of some giant clams may reach a length of 1 m (39 in) and a weight of 200 kg (440 lb).

Many mollusk shells are commercially important by virtue of their beauty and rarity. Shells of more common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(Opposite page) *Many shells are considered collector's items: the melon shell* (A); *the true tulip shell* (B); *the venus's comb* (C); *the hawk-wing conch* (D); *the tiger cowrie* (E); *the common file shell* (F); *the costate cockle* (G); *a drupe* (H) *of the family Thaididae; the Atlantic dogwinkle* (I); *a turret shell* (J) *of the family Turritellidae; the marbled cone* (K); *the pelican's foot conch* (L); *the golden-mouth turban shell* (M); *the warty venus clam* (N); *the orange-mouth scorpion conch* (O); *the queen scallop* (P); *the noble pin shell* (Q); *the strawberry top shell* (R) *of the family Trochidae; the papal miter shell* (S); *the king's crown conch* (T); *and the sunrise tellin* (U).

mollusks have long been used for the production of synthetic pearls, pearl buttons, and other decorative items.

Shell collecting, usually confined to molluscan shells, is popular in many parts of the world. Shells have long been used for ornamentals, tools, and coins because of their bright colors, great variety in shape, and abundance.

Seashells are found in all oceans, from the shoreline to the deepest depths. The world's richest region, with regard to numbers of species, is the Indo-Pacific. The most sought-after marine shells are the cones, family Conidae; cowries, Cypraeidae; volutes, Volutidae; and rock shells, Muricidae.

Collectors, or conchologists (the study of shells is called conchology), search for specimens with excellent qualities and rarity, although the standards for judging vary. For some, rarity is judged by the high price a specimen can bring. For others, rarity of a specimen is judged by its scarcity in nature or in collections. Most of the truly rare species are deep-sea shells, of which only a single specimen may have been found.

shellac Shellac was one of the first RESINS used by humans. *Lac,* the name for the basic resin, is believed to be the basis for the term *lacquer.* (The first lacquers, used in China and Japan, were exudates from a variety of sumac trees; shellac was introduced later as a substitute.)

Lac is a hard, resinous secretion from the scale insect *Laccifer lacca,* found largely in Southeast Asia, including sections of India. The insect's life cycle extends for approximately 6 months, at which time the lac is separated through various heat, solvent, and filtering methods, dried into sheets, and pulverized into flakes.

Shellac ranges from a light yellow, which is preferred, to a deep orange; the color is highly dependent on the variety of the host tree and the extent of purification. It is most frequently supplied as a solution cut in alcohol. Insoluble in petroleum spirits, the resin is ideally suited as a stain-suppressing sealer under conventional solvent-based coatings. Shellac was formerly used in considerable volume as a binder for phonograph records and continues to be an important resin for lithographic printing inks and as a coating for candy, pills, and fruit.

Mary Wollstonecraft Shelley, the wife of the poet Percy Bysshe Shelley, appears in this portrait by R. Rothwell. In 1816 she, her husband, and Lord Byron were challenged to compose a horror story; the two poets shortly gave up. Mary Shelley's effort, Frankenstein *(1818), has become a classic Gothic horror tale.*

Shelley, Mary Wollstonecraft Daughter of political philosopher William Godwin and women's-rights advocate Mary Wollstonecraft and second wife of the poet Percy Bysshe Shelley, Mary Wollstonecraft Shelley, b. London, Aug. 30, 1797, d. Feb. 1, 1851, is famous as the author of *Frankenstein* (1818), a novel whose popularity as a horror tale has eclipsed its philosophical content. On the death (1822) of her husband, Mary Shelley devoted herself to her child and to literary work. Returning (1823) to England, she edited Shelley's works and her own *Journals* and letters, which, with Shelley-related material in her other works, are an important source for later commentators. Often using views and characters derived from Shelley and his friends but uneven in quality, her works include *History of a Six Weeks' Tour* (1817), *The Last Man* (1826), and the autobiographical *Lodore* (1835).

Shelley, Percy Bysshe Percy Bysshe Shelley, b. Aug. 4, 1792, d. July 8, 1822, stands with Coleridge, Wordsworth, Keats, and Byron as one of the great English romantic poets.

Shelley was educated at Eton, then expelled from Oxford for publishing an anti-Christian pamphlet called "The Necessity of Atheism" (1811). He eloped to Ireland

Percy Bysshe Shelley, one of the greatest English romantic poets, wrote philosophical, but intensely lyrical verse. His works, such as "Ode to the West Wind" and Prometheus Unbound, *express his devotion to natural beauty and Platonic ideals.*

that same year with 16-year-old Harriet Westbrook, by whom he had a son and a daughter. Three years later Shelley eloped again, this time with Mary Wollstonecraft Godwin, whom he married in 1816 after Harriet committed suicide. He and Mary had four children, only one of whom survived. Leaving England for the last time in 1818, Shelley settled in Italy, forming in Pisa a radical circle of friends described in his ecstatic vision of free love, *Epipsychidion* (1821). He drowned in 1822, not yet 30 years old, when his boat, the *Don Juan*, capsized on its way to San Terenso, his last Italian residence. Shelley was cremated, and his remains were buried in the Protestant cemetery in Rome where his friend Keats had been interred a year earlier.

Shelley's tempestuous career may be divided into three periods. In the early period (1810–15) he published radical pamphlets; two Gothic novels, *Zastrozzi* and *St. Irvyne* (both 1810); *Queen Mab* (1813), an early radical poem with lengthy notes on a wide range of political, economic, social, and religious topics; and his first major work, *Alastor; or, The Spirit of Solitude* (1816). *Alastor* is the most enigmatic of Shelley's admittedly difficult poems. It deals with a visionary poet's search throughout a labyrinthine, increasingly nightmarish landscape for a veiled maid erotically encountered in a dream. Failing to find this ideal in the external world, he descends "to an untimely grave," hoping perhaps to find in death what he could not find in life.

Shelley's middle period (1816–21) is marked by a brilliant development of lyric power in such poems as "Hymn to Intellectual Beauty," "Mont Blanc," "Ozymandias," "Ode to the West Wind," "The Cloud," "To a Skylark," and "Ode to Liberty." This development culminates in *Prometheus Unbound* (1819), a four-act lyrical drama that, unlike *Alastor*, celebrates the apocalyptic fulfillment of desire in the victory of Prometheus over all the tyrannical forces that oppose the creative imagination, symbolized by the fire that Prometheus steals from Jupiter and bestows on humankind. The prose counterpart of Shelley's lyrical drama is *A Defence of Poetry* (1821), in which he defends well his own poetry, brilliantly explores the whole history of European poetry, and provides an impassioned defense of English romanticism.

Shelley's final period (1821–22) is marked by two major poetic achievements—*Adonais* (1821), a pastoral elegy on the death of Keats, and *The Triumph of Life* (1822), a poem showing every sign of brilliant construction though left unfinished at the time of his death. In both these works, as well as in "occasional" pieces, Shelley's visionary idealism assumes a greater otherworldly goal (also apparent earlier in *Alastor*), presented as an object of poetic rather than religious faith. The actualization of that innate and insatiable desire for immortality resides for Shelley in its poetic articulation, which in turn will inspire political reform.

shellfish The word *shellfish* is a commercial rather than a scientific term and refers to hard-covered, edible, mostly marine animals from two different groups: the mollusks (oysters, clams, mussels) and the crustaceans (crabs, lobsters, and, sometimes, shrimp). The U.S. shellfish fishery and shellfish culture (aquaculture) are among the largest, oldest, and most developed in the world.

Mollusks

Among the important mollusk species, harvested from both wild and cultivated stocks, are oysters, hard-shell clams, surf clams, soft-shell clams, razor clams, and horse clams.

The edible Virginia oyster, *Crassostrea virginica*, thrives in estuaries and ranges on the eastern coast of North America from Mexico to Canada. Naturally produced seed oysters (small oysters suitable for transplanting) from densely populated estuaries are planted on both public and private oyster-growing areas. Aquacultural activities account for about 40 percent of the U.S. oyster harvest.

The fishery for hard-shell (thick-shelled) clams, such as the quahog, *Mercenaria mercenaria*, is the oldest and largest of the clam industries in the United States in terms of fishers and fishing craft. Most of the hard-shell clams are harvested by hand-digging with forks or rakes during low tides; the bulk of the catch originates from the East Coast.

Most of the American surf-clam industry is in the New England and mid-Atlantic states. The surf clam, *Spisula solidissima*, is harvested by dredging vessels. Overfishing and massive mortality caused primarily by waste contamination have reduced surf-clam resources drastically in some waters in recent years.

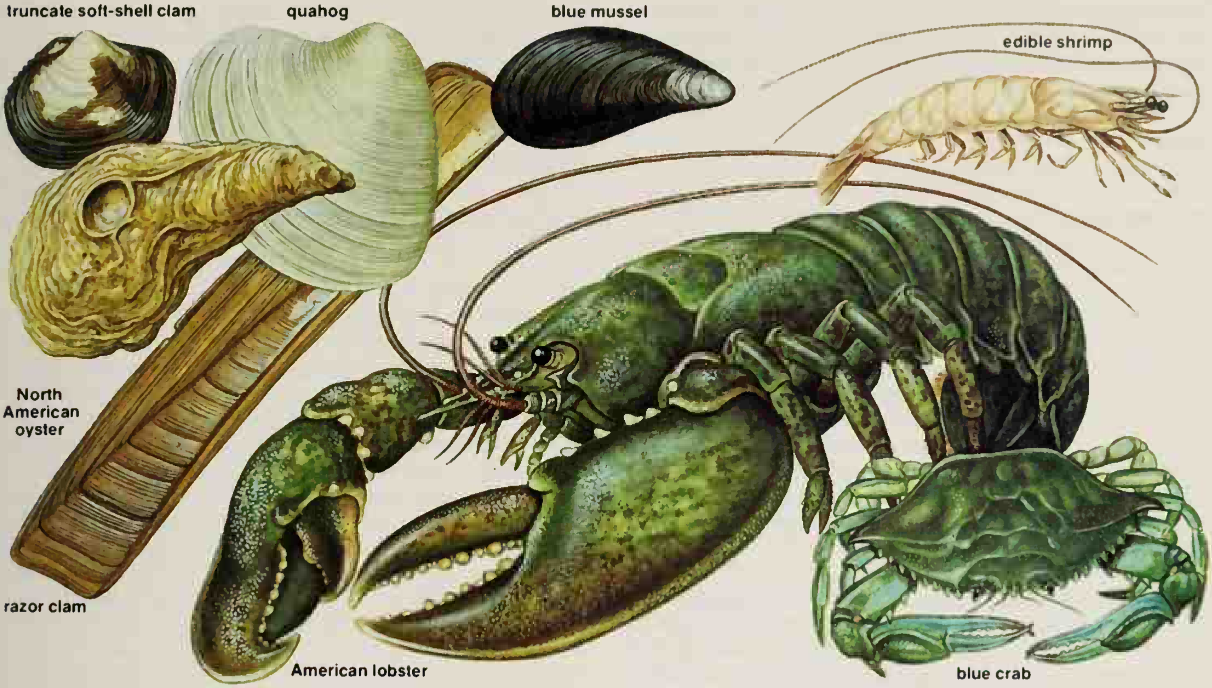
The ocean quahog, *Arctica islandica*, is found in greatest abundance off the coast of Long Island (N.Y.) in waters 25–60 m (80–200 ft) deep. Its meat is darker than that of the surf clam and has a stronger taste.

The sand gaper, a soft-shell (thin-shelled) clam, *Mya arenaria*, is harvested with escalator dredges off the Maryland and New England coasts. It is also dug with rakes or forks during low tides. Because this clam exists in very shallow water, pollution, particularly in New England, is a serious threat.

Along the West Coast, razor clams, *Siliqua* and others, and horse clams, *Modiolus*, are harvested in intertidal waters. The geoduck clam, *Panopea*, is the world's largest burrowing bivalve, weighing up to 5 kg (11 lb). The blue mussel, *Mytilus edulis*, found along both coasts, is receiving increased attention as the supply of clams dwindles. Its use, however, is impaired by the intermittent appearance of paralytic shellfish poisoning among consumers, although in almost all cases potentially dangerous periods are detected and products withheld from the market. Most of the shellfish in shallow water can be subject to aquaculture; the obstacles are coastal pollution and natural predators, such as birds and starfish.

Crustaceans

In commerce, shrimp are often included in the category of shellfish. Shrimp landings are first in value and third in abundance of all shellfish landings in the United States. Shrimp are caught with beam trawls along all the coasts, although most landings originate from the Gulf Coast and



Edible bivalve mollusks include the blunt gaper, a soft-shell clam, circumpolar in distribution; quahog, a hard-shell clam, of the Atlantic coast of North America; blue mussel, eaten mainly in Europe; North American oyster, which develops a rough, massive shell; and common razor clam, ranging from Labrador to Georgia. Commercially important crustaceans include the American lobster, which may reach 90 cm (3 ft) in length; edible shrimp; and blue crab, found in waters from Cape Cod to Uruguay.

lately from the Kodiak area in the Gulf of Alaska.

Among the larger shellfish crustaceans, the American lobster, *Homarus americanus*, has been the most important commercially. This lobster occurs from Labrador to Cape Hatteras. It lives in shallow water, typically on rocky bottoms, and is caught in baited lobster pots. Most of the American catch of lobster comes from Maine. A smaller species, *Palinurus*, known as spiny lobster or langousti, is taken in Florida and off California in smaller quantities.

Crabs are caught in baited crab pots. The American crab fisheries for blue crab, *Callinectes sapidus*, off the Atlantic coast and for dungeness crab, *Cancer magister*, off the West Coast have declined because of overfishing and pollution. Intensive fishery for king crab, *Paralithodes camtschaticus*, started in the Bering Sea in the late 1950s, employing both baited pots and otter trawls. King-crab stocks have been in decline since the early 1970s. The fishery has therefore switched to a smaller but more abundant crab in the Bering Sea and the Gulf of Alaska: the snow, or Tanner, crab, *Chionoecetes*.

All shellfish fisheries are controlled through regulations governing season length, catch quotas, and minimum size, to prevent the depletion of the stocks.

Shen Zhou (Shen Chou) [shen joh] Shen Zhou, 1427–1509, was a Chinese scholar-painter and leading master of the Wu school of painting, named for Shen's birthplace, Wuxian. Although he was wellborn and received a traditional Confucian education, Shen eschewed an official career in government and dedicated his life instead to aesthetic and intellectual pursuits.

His paintings show an indebtedness to the Four Great Masters of the Yuan period (1279–1368), particularly HUANG GONGWANG and Wu Zhen. Shen, however, evolved a highly personal style, differentiated from that of his predecessors above all by the sense of human warmth that permeates his works.

Shen-yang see SHENYANG

Shenandoah River [shen-uhn-doh'-uh] The Shenandoah River, a shallow, winding river in northern Virginia, is 242 km (150 mi) long. It is formed at Front Royal by the confluence of the longer South Fork, which rises in the Alleghenies near Staunton, and the North Fork, which originates in the high ridges of Shenandoah County. The main stream then flows northeast for 90 km (55 mi) to its mouth at Harpers Ferry, W.Va., on the POTOMAC RIVER. The Shenandoah Valley, bordered by the Alleghenies on the west and the Blue Ridge Mountains on the east, supports cattle and poultry farming and extensive apple orchards.

Explored as early as 1716, the valley was soon settled and became an important corridor for westward expansion. Harpers Ferry was the site of the abolitionist John Brown's raid in 1859; several Civil War battles were fought along the river.

Shensi see SHAANXI

Shenyang (Shen-yang) [shuhn-yahng] Shenyang (known in Manchu as Mukden) is the largest city and industrial center of northeastern China and the capital of Liaoning province (see MANCHURIA). The city has a population of 4,440,000 (1989 est.). Shenyang is located in the eastern part of the Liao River plain, about 650 km (400 mi) northeast of Beijing. The city's proximity to rich mines—iron in Anshan and coal in Fushun—partly accounts for its industrial growth. Major manufactures include machinery and transportation equipment, metal products, chemicals, electrical appliances, textiles, paper, and processed food. The city is also the cultural and transportation center of the province. The former Manchu Imperial Palace is now a public garden.

From 1625 to 1643, Shenyang was the political center of the Manchus, who subsequently conquered China to found the QING dynasty (1644–1911), with Beijing as its capital. The Manchu emperors periodically returned to their former capital to pay homage to their ancestors interred there. In 1931 the Mukden Incident (see SINO-JAPANESE WARS) near the city resulted in Japan's occupation of Mukden and all of Manchuria, which it held until 1945 as Manchukuo. Shenyang fell to Communist forces in 1948.

Shepard, Alan B., Jr. The astronaut Alan Bartlett Shepard, Jr., b. East Derry, N.H., Nov. 18, 1923, was the first American launched into space and the fifth man to walk on the Moon. Shepard earned his B.S. degree from the U.S. Naval Academy in 1944 and served aboard a destroyer before becoming (1950) a test pilot. He was serving as aircraft readiness officer at Atlantic Fleet Headquarters in Norfolk, Va., when he was selected in 1959 to become one of the original seven astronauts.

Alan Shepard was one of the original seven men chosen in 1959 to train as astronauts for the U.S. space program (called Mercury). He is seen in the spacesuit he wore aboard Freedom 7 *on May 5, 1961, when he became the first American in space. Shepard also commanded the* Apollo 14 *mission (1971) to the Moon and spent 4½ hours exploring the lunar surface.*

Shepard's first flight in space was a suborbital trip (May 5, 1961) aboard *Freedom 7* (*Mercury-Redstone 3*). The 15-minute flight went 187.4 km (116.5 mi) high and 487.2 km (303.8 mi) downrange in the first manned test of the MERCURY PROGRAM. An inner-ear disorder barred him from later flights until surgery corrected the problem in 1969. His second flight in space was as commander of *Apollo 14* (Jan. 31–Feb. 9, 1971), the third manned mission to the Moon.

Shepard served (1963–69, 1971–74) as chief of the astronaut office at the Johnson Space Center. He retired from the navy as a rear admiral and from NASA in 1974.

Shepard, Ernest Howard The British artist and cartoonist Ernest Howard Shepard, b. Dec. 10, 1879, d. Mar. 24, 1976, is best known as the illustrator of A. A. Milne's children's classics *Winnie-the-Pooh* (1926) and *The House at Pooh Corner* (1928). In 1924 he became senior editor of the periodical *Punch*, to which he had contributed drawings. Shepard illustrated almost 50 books, including Kenneth Grahame's *The Wind in the Willows* (1931).

Shepard, Sam The multitalented Sam Shepard, b. Samuel Shepard Rogers in Fort Sheridan, Ill., Nov. 5, 1943, is recognized as one of 20th-century America's great playwrights, as well as a highly respected and popular film actor. The winner of 11 Obie Awards for his dramas, Shepard fuses in many of them past and future, myth and actuality, in an often nightmarish vision of American culture grappling with the onset of high technology. A strong rural American idiom emerges in his plays, especially in the so-called family trilogy—*Curse of the Starving Class* (1977), *Buried Child* (1978; Pulitzer Prize), and *True West* (1980). Others include *Operation Sidewinder* (1970), *The Tooth of Crime* (1972), *Fool for Love* (1983; film, 1985), and *A Lie of the Mind* (1985), which Shepard directed in New York City.

Shepard the film actor—whose screen presence has been likened to that of Gary Cooper—made his debut in *Days of Heaven* (1978) and later played noteworthy roles in *Resurrection* (1980), *Frances* (1982), *The Right Stuff* (1983; as Chuck Yeager), *Country* (1984), and his own *Fool for Love*.

Sheraton, Thomas Thomas Sheraton, b. 1751, d. Oct. 22, 1806, was the most prolific designer of furniture in England at the end of the 18th century and was noted for his books of furniture designs. The first and most successful was *The Cabinet-Maker and Upholsterer's Drawing Book* (1791–94). The others were *The Cabinet Dictionary* (1803) and the incomplete *Cabinet-Maker, Upholsterer, and General Artist's Encyclopaedia* (1805), which Sheraton did not live to finish. The books illustrate English neoclassical furniture fashions of the pre-Regency period and the square and rectangular forms of the Sheraton style.

Sheraton's *Drawing Book* designs show a preference for simple, severe outlines and flat surfaces decorated with borders of cross-banding and black or brass stringing lines inlaid in simple geometrical patterns. In his later designs, Sheraton introduced classical Greco-Roman devices—curved sabre legs for tables and chairs, sculpted scrolls and volutes, and animal forms used as supports and terminals.

Sherbrooke [shur'-bruk] Sherbrooke (1986 pop., 74,438), a Canadian city in southern Quebec, is located about 150 km (95 mi) east of Montreal. The city produces textiles, rubber, steel, pulp, and paper. It is also a winter sports center. The Université de Sherbrooke (1954) is located there. Sherbrooke was founded in 1794 on the site of a fur trading post where American Loyalists had settled both during and following the Revolutionary War.

Sheridan, Philip H. Philip Henry Sheridan, b. Albany, N.Y., Mar. 6, 1831, d. Aug. 5, 1888, an aggressive soldier during the U.S. Civil War, later became general in chief of the U.S. Army. After clerking in a store, he entered (1848) the U.S. Military Academy at West Point. He was suspended for participating in a fracas but graduated in 1853 and served on the frontier.

When the Civil War began, Sheridan served as federal quartermaster in southwestern Missouri and participated in Henry HALLECK's advance on Corinth, Miss., in the spring of 1862. As a division commander he held his position against Confederate attacks at Perryville, Ky. (October 1862) and at Stones River, Tenn. (December 1862–January 1863). He was unable to maintain his lines at CHICKAMAUGA in September 1863 but redeemed himself in November by storming Missionary Ridge at Chattanooga (see CHATTANOOGA, BATTLES OF), where his combativeness and leadership qualities attracted the favorable attention of U.S. Gen. Ulysses S. GRANT.

Philip Henry Sheridan, a Union general in the U.S. Civil War, devastated the fertile Shenandoah Valley to prevent its use by Confederate troops. Soon afterward, he forced Robert E. Lee's final retreat to Appomattox.

In early 1864, Grant brought Sheridan east as commander of the Army of the Potomac's cavalry, which Sheridan reorganized. After fighting in the WILDERNESS CAMPAIGN (May 1864), he made a partially successful raid near Richmond, Va., that captured supplies and resulted in the death of the dynamic Southern cavalry leader J. E. B. STUART. In command of the Army of the Shenandoah during the autumn of 1864, Sheridan finally pushed Jubal EARLY's Confederate forces out of Virginia's Shenandoah Valley. Rejoining Grant and George G. MEADE, he scored significant victories at Five Forks and Sayler's Creek (both in Virginia) in the spring of 1865, thereby helping to compel Confederate general Robert E. Lee to surrender.

Following the war Sheridan served (1867) along the Rio Grande. After being relieved (1867) of his post as military governor of Louisiana and Texas because of excessive harshness, he led (1868–69) a series of campaigns against the Indians in the West and accompanied (1870) the Prussian army as an observer during the Franco-Prussian War. He was general in chief from 1883 until his retirement in 1888.

Sheridan, Richard Brinsley The most highly regarded English playwright of the 18th century, Richard Brinsley Sheridan, b. Dublin, Oct. 31, 1751, d. July 7, 1816, was also a politician of note. He was born into a family with theatrical connections and received his formal education at Harrow. In 1772 he eloped to the Continent with Elizabeth Linley, a singer, and married her the following year. Then began the production, in rapid succession, of the plays that made his reputation. His first play, *The Rivals* (1775), a comedy mixing farcical action and romantic sentimentality, was followed by *St. Patrick's Day*, a two-act farce, and *The Duenna*, a comic opera, both of which appeared later in 1775. In 1776 Sheridan bought a partnership in the Drury Lane Theatre and assumed its management. *A Trip to Scarborough*, adapted from Sir John Vanbrugh's *The Relapse* (1697), and *The School for Scandal*, generally considered his greatest play, were produced at Drury Lane in 1777. In *The School for Scandal* Sheridan wittily suggested that society's concern with the appearance of respectability masked deceit and backbiting malevolence. *The Critic* (1779), a burlesque of heroic drama, was his last comedy.

In 1780, Sheridan was elected to Parliament and in 1783 became secretary of the treasury. A noted orator, he held a succession of government posts during the next three decades, although party leadership eluded him. *Pizarro*, an undistinguished tragedy adapted from a German play by August von Kotzebue, appeared in 1799. His political fortunes eventually declined, however, and he fell into debt late in life. He died in London and was buried in Westminster Abbey.

sheriff The chief law enforcement official in a U.S. county is the sheriff. Usually elected, the sheriff serves as an officer of the county courts and is responsible for delivering writs, summonses, and warrants; carrying out court judgments; and maintaining the county jail. The sheriff also preserves the peace in areas not under municipal police control. Some sheriffs receive an annual salary, while others receive fees for each service performed or a combination of fees and salary.

Sheriffs have slightly different functions in other countries. In England, for example, one of the sheriff's duties is to preside at parliamentary elections for the county. The office of sheriff has its origins in pre-Norman England where royal authority in the shire, or county, was represented by a high official called the reeve. The *shire reeve* eventually became known as the sheriff.

Sherman, James Schoolcraft James Schoolcraft Sherman, b. Utica, N.Y., Oct. 24, 1855, d. Oct. 30, 1912, was vice-president of the United States (1909–12) under William Howard Taft. He also served several terms (1887–91, 1893–1909) in Congress as a conservative Republican from New York. Although he proposed measures to improve the conditions of American Indians and called for government aid to build an interoceanic canal in Nicaragua, Sherman was primarily concerned with the mechanics of parliamentary procedure. He was nominated for a second vice-presidential term but died three days before the election.

Sherman, John John Sherman, b. Lancaster, Ohio, May 10, 1823, d. Oct. 22, 1900, younger brother of Gen. William Tecumseh Sherman, was a leading American statesman. He showed remarkable longevity as a federal officeholder, serving as representative (1855–61), senator (1861–77, 1881–97), secretary of the treasury (1877–81), and secretary of state (1897–98).

A financial expert with a conservative ideology, Sherman was usually able to develop legislative compromises by granting small concessions to his radical adversaries. As secretary of the treasury under President Rutherford B. Hayes, Sherman brought about the resumption of payment in hard money for government debts. He yielded to soft-money pressure, however, by supporting the BLAND-ALLISON ACT of 1878.

His mastery of the art of political compromise never brought him the Republican presidential nomination he sought in 1880, 1884, and 1888, but he had a record unparalleled in his time as the architect of major legislation, notably the SHERMAN ANTI-TRUST ACT and the Sherman Silver Purchase Act, both passed in 1890. He was less in his element as President William McKinley's secretary of state, resigning in 1898 when his health began to fail, and the administration became committed to war with Spain.

Sherman, Roger Roger Sherman, b. Newton, Mass., Apr. 19, 1721, d. July 23, 1793, was an American statesman and signer of the Declaration of Independence. He was a Connecticut delegate to the First and Second Continental congresses, and mayor of New Haven (1784–93). At the CONSTITUTIONAL CONVENTION (1787) he played a leading role in arranging the Connecticut Compromise, establishing two houses of Congress, one with two representatives from each state, the other with representation proportional to population. Sherman was later a U.S. representative (1789–91) and senator (1791–93).

Sherman, William Tecumseh A renowned Union general during the U.S. CIVIL WAR, William Tecumseh Sherman, b. Lancaster, Ohio, Feb. 8, 1820, d. Feb. 14, 1891, was among the first military leaders to recognize and put into practice the methods that became the tenets of modern warfare.

Sherman graduated sixth in his class at West Point in 1840. As a staff officer in California during the Mexican War he won a brevet for meritorious service, but he resigned from the army in 1853 and held various jobs, including superintendent of a military academy at Pineville, La. (later Louisiana State University at Baton Rouge).

At the start of the Civil War the fiery-tempered Sherman rejoined the army as a colonel and commanded a brigade at the First Battle of BULL RUN (July 1861). In September he headed a military department at Louisville, Ky., where he clashed with newspaper correspondents over the need to maintain military secrecy. Overruled by Lincoln when he ousted reporters from the camp, Sherman suffered a nervous breakdown and was subsequently transferred to a post in Missouri.

Never a great battle captain, Sherman, in command of a division in Ulysses S. GRANT's army at the Battle of SHILOH (April 1862), was surprised and almost defeated by a fierce Confederate attack launched by Albert Sidney JOHNSTON. Nor was Sherman more successful when his preliminary advances from the north against the great Confederate stronghold of Vicksburg, Miss., were repelled at Chickasaw Bayou. Under John A. McClernand, however, Sherman played an important role in the seizure of Arkansas Post and later assisted Grant at Vicksburg in July 1863 (see VICKSBURG CAMPAIGN). At the Battle of CHATTANOOGA in November 1863, Sherman's assaults were repulsed, but the Union forces won the engagement.

When Grant became general in chief, Sherman commanded the large Union army of approximately 100,000 men that moved southeast from Dalton, Ga. Although roundly defeated in rash attacks at Kenesaw Mountain, he captured Atlanta in September 1864 after a long series of cat-and-mouse contests with Joseph E. JOHNSTON (see ATLANTA CAMPAIGN). An aggressive leader, Sherman was expert in planning and executing long marches and in mastering difficult logistical problems. Spreading out his army about 80 km (50 mi) wide, he conducted a scorched-earth campaign against the Confederacy, ravaging the unprotected Georgia countryside in the famous March to the Sea (Nov. 16–Dec. 22, 1864) that resulted in the capture of Savannah. Agreeing that "War is hell," he nonetheless used the same pillaging tactics in striking northward through the Carolinas in early 1865, and his campaign, after a Union victory at Bentonville, compelled Johnston to surrender at Durham Station, N.C., in April.

William Tecumseh Sherman, a Union general in the U.S. Civil War, has been called the first modern general for his grasp of the strategic importance of widespread destruction, which not only depletes the enemy's economic resources but undermines civilian morale as well. He demonstrated this most notably in his March to the Sea across Georgia.

In 1869, Sherman was advanced to full general and succeeded Grant as general in chief of the army, a post he held until 1883. Sherman established (1881) the world-famous school at Fort Leavenworth, Kans., that became known as the Command and General Staff College. He retired from the army in 1884 and declined all offers of high political office, saying: "I will not accept if nominated and will not serve if elected."

Sherman Anti-Trust Act One of the great landmarks in the development of the U.S. government-business relationship, the Sherman Anti-Trust Act of 1890 was enacted by Congress to prohibit trusts and combinations in restraint of trade or commerce among states or with foreign nations. The act, named for Senator John Sherman, was the first federal law designed to deal with what was perceived as a growing centralization of economic power by monopolistic corporations (see MONOPOLY AND COMPETITION). The Department of Justice enforces the act, although private parties also may bring actions under the act.

At first the Sherman Act was rendered ineffective by Supreme Court decisions such as in *United States* v. *E. C. Knight Company* (1895). The act's provision for federal injunctions, however, was used against unions until the Norris–La Guardia Act of 1932. President Theodore Roosevelt's "trust-busting" oratory, the creation (1903) of the Antitrust Division in the Department of Justice, the establishment (1914) of the FEDERAL TRADE COMMISSION, and the passage of the Clayton Anti-Trust Act (1914) and the ROBINSON-PATMAN ACT (1936) revived and expanded the Sherman Act. Numbered among the act's major achievements are the dissolution of Northern Securities Company (1904), the Standard Oil Trust (1911), and the American Tobacco Company (1911).

See also: GOVERNMENT REGULATION.

Sherpa [shur'-puh] The Sherpa are an ethnic group in northeastern Nepal. They inhabit several high valleys, at altitudes between about 2,400 and 4,000 m (8,000 and 13,000 ft), in a region called Solu-Khumbu, on the southern slopes of the central Mount Everest ridge. In the 16th and 17th centuries they migrated to their present home from Khams, an eastern province of Tibet. Their name is derived from *sherwa* (spelled *sharpa* in Tibetan), "eastern one." They are closely linked to Tibetan culture, speaking a Tibetan dialect and practicing TIBETAN BUDDHISM of the unreformed *rnyingmapa* sect.

The traditional mode of life of the Sherpa is based on the herding and breeding of yaks, cows, and crossbreeds; on trade across the Himalayas; and on field-crop agriculture. The present Sherpa economy depends largely on Western tourism and mountaineering because Sherpas serve as guides, high-altitude porters, and climbers on treks and mountaineering expeditions in the Himalayas. Significant populations of Sherpas have settled in Indian hill stations such as Darjeeling and Kalimpong, where they take wage-laboring jobs on tea plantations and road-building gangs. The Sherpa population was about 25,000 in 1980.

sherry Sherry, a blended, fortified wine, originally was made only in the Andalusian province of coastal southwest Spain, around the city of Jerez de la Frontera; today other countries also market products called sherry, but it is often dissimilar to the original. Grapes, particularly of the Palomino variety, are harvested and pressed, and the expressed juice is placed in casks made of American white oak. The casks are stored in buildings known as bodegas where, over a period of about ten weeks, the juice ferments into a completely dry wine. This wine is then fortified with brandy and passed into fresh casks to age. A yeast known as *flor del vino* ("flower of the wine") may grow in the wine; if the flor develops, the wine will become a *fino* (dry and light), and if the flor does not develop, the sherry will become an *oloroso* (slightly sweet).

The next step, known as the *solera* process, involves blending sherry of the type desired from different rows of casks. The bottom row comprises wine as old as 100 years, and the younger rows are stacked on top. Sherry is drawn from various rows and blended. Thus no such thing as vintage sherry exists. Amontillados are medium sherries, the best of which are aged *finos*. Manzanilla is the palest and driest sherry, and a cream sherry is an aged *oloroso* that is very sweet.

's Hertogenbosch [sair-toh-kuhn-baws'] The city of 's Hertogenbosch (also called Den Bosch) is the capital of the province of North Brabant in the southern Netherlands. The population is 89,039 (1986 est.). About 80 km (50 mi) southeast of Amsterdam, the city is linked with Belgium by the Zuid-Willemsvaart Canal. Ships, bicycles, footwear, and tobacco products are manufactured there. The 15th-century cathedral is the largest Roman

Catholic church in the country. Probably settled during the 12th century, the city was an important wool market. During the Dutch Revolt, the city suffered many sieges until Frederick Henry of Orange took it from Spain in 1629. It was held by France from 1794 until 1814. The painter Hieronymus Bosch was born there about 1450.

Sherwood, Robert E. Notable especially for his forceful dialogue, playwright Robert Emmett Sherwood, b. New Rochelle, N.Y., Apr. 4, 1896, d. Nov. 14, 1955, won attention in the 1930s with his sensitive, grimly heroic dramas. In *The Petrified Forest* (1935) he laid bare the dreams of characters caught up in the Great Depression. His next three plays, *Idiot's Delight* (1936), *Abe Lincoln in Illinois* (1938), and *There Shall Be No Night* (1941), all won the Pulitzer Prize. A film critic from 1920 to 1928, Sherwood later received an Academy Award for his moving screenplay for Hollywood's *The Best Years of Our Lives* (1946). A fourth Pulitzer Prize was awarded his biographical study *Roosevelt and Hopkins* (1948).

Sheshonk I, King of Egypt [shee'-shahnk] Sheshonk I, first king (r. *c.*935–*c.*914 BC) of Egypt's 22d dynasty, was probably of Libyan descent. His victories in Palestine against the Israelites are commemorated on the walls of his temple at Karnak and mentioned in the Bible (2 Chronicles 12:9; I Kings 14:25–27), where he is called Shishak. Challenging the right of King Solomon's son, REHOBOAM, to become king of the Israelites, Sheshonk supported the pretender JEROBOAM and later raided Palestine, receiving the temple treasures as tribute from Rehoboam. His tomb at TANIS has been excavated.

Shetland Islands The Shetland Islands, lying 170 km (105 mi) northeast of Scotland in the North Sea, consist of about 100 islands and islets, most of them uninhabited. The northernmost point of the British Isles, the Shetlands have a total land area of 1,432 km^2 (553 mi^2) and a population of 22,400 (1988 est.). Lerwick, the present capital, and Scalloway, the ancient capital and a fishing center, are located on the largest island, Mainland. Economic activities include sheep raising, fishing, and the export of Shetland ponies. The local sheep produce the well-known Shetland wool. Some vegetables, oats, barley, and potatoes are grown. The Picts, who colonized the islands in about 200 BC, were converted to Christianity during the 7th century AD. In the 8th century the islands were invaded by Vikings, who ruled until the 15th century. Since 1472 the Shetlands have belonged to Scotland.

Shetland pony see HORSE

Shetland sheepdog The Shetland sheepdog, which resembles a miniature collie, originated in the Shetland Islands as a working sheepdog. Shelties are small and rough-coated and must be sturdy and agile. The ideal sheltie stands from 33 to 41 cm (13 to 16 in) at the shoulder. The coat is similar to the collie's, consisting of a long, straight, harsh outercoat and a short, dense undercoat. Shelties may be black, blue, merle, sable (ranging from golden to mahogany), or tricolored, with white or tan markings. The breed has long been one of the most popular in the United States. Shelties were first recognized by the English Kennel Club as Shetland collies in 1909 and as Shetland sheepdogs in 1914.

The Shetland sheepdog originated in the Shetland Islands, off the coast of Scotland. A small, working farm dog, the sheltie, as it is known, is still used as a guardian of flocks and family throughout the British Isles.

Shevardnadze, Eduard [she-vahrd-nahd'-ze] Eduard Shevardnadze, b. Jan. 25, 1928, was foreign minister of the USSR from 1985 to 1991. Before being named to that post he was first secretary of the Communist party in his native Georgia. A close collaborator with Soviet leader Mikhail Gorbachev, Shevardnadze showed himself to be a skilled diplomat in his dealings with the West. Warning that the Soviet Union was again heading toward dictatorship, Shevardnadze resigned in December 1990 but continued as foreign minister in a caretaker capacity until he was replaced by Aleksandr Bessmertnykh in January 1991.

Shigella [shuh-gel'-uh] Named for Kiyoshi Shiga (1871–1957), a Japanese bacteriologist, *Shigella* is a genus of rod-shaped bacteria. The normal habitat of all species is the intestinal tract of humans, primates, and, rarely, dogs. *Shigella* can cause human DYSENTERY, a disease transmitted by infected food or water.

shih tzu [sheed zoo] The shih tzu, native to Tibet, is a small, active toy breed of dog. Like the Lhasa apso, it is covered with a luxurious, long, dense coat that may be slightly wavy but not curly. The hair on the head is tied. Any color is permitted; usually there are white markings. The breed stands from 20 to 28 cm (8 to 11 in) at the withers and weighs 5.5 to 7 kg (12 to 15 lb). The shih tzu was known in China at least as early as AD 624. The first pair was brought to England in 1930. The shih tzu was

The shih tzu is a toy dog with a long, flowing coat and a plumed tail carried high over its back. Originating in Tibet, shih tzus were given as gifts to the Chinese emperors. They became favored royal pets.

officially recognized by the English Kennel Club in 1946 and by the American Kennel Club in 1969. It now is among the most popular toy breeds.

Shih-t'ao see SHITAO

Shiites [shee'-yts] The Shiites (a name derived from the Arabic *shiat Ali*, "the party of Ali") constitute one of the two major branches of ISLAM, the other, larger branch being the SUNNITES. Following the death of MUHAMMAD, disagreement arose as to the necessary qualifications and exact function of his successors as leaders (IMAMS) of the Muslim community. The Shiites are those who insisted that only members of the Prophet's clan, specifically, the descendants of Muhammad's daughter FATIMA and her husband ALI, could qualify. Although Ali became (655) the fourth caliph (see CALIPHATE), he was murdered in 661, and the majority recognized the Umayyad MUAWIYA I as caliph. The Shiites, however, supported the claims of Ali's sons: Hasan, who died mysteriously *c.*669, and Husayn, who was killed by Umayyad troops at Kerbala in 680 (Kerbala, in Iraq, became the major pilgrimage center for the Shiites).

Shiism has three major subdivisions as well as numerous offshoots. The majority are called Twelvers (*Ithna Ashariyya*), because they recognize 12 imams, beginning with Ali; the 12th disappeared in 873 but will return as the MAHDI (messiah). Twelver Shiism became the state religion of Persia (Iran) under the Safavid dynasty in the 16th century; it retains that position in the present-day Islamic republic of Iran. The other two major subdivisions are the Seveners (see ISMAILIS) and the Fivers (Zaydites).

Shiism emphasizes the spiritual function of the Prophet's successor, the imam, in whom the Prophetic Light is ever present in this world. He is believed to be divinely protected against sin and error and to have an infallible understanding of the Koran, a supernatural knowledge of future events, and intercessory powers.

Shikoku [shi-koh'-koo] Shikoku is the smallest of the four principal Japanese islands. Located south of Honshu and northeast of Kyushu, with the southern and eastern coasts facing the Pacific Ocean, mountainous Shikoku has an area of 18,780 km^2 (7,251 mi^2) and a population of 4,218,000 (1989 est.). Mount Ishizuchi, the highest peak, rises to 1,980 m (6,500 ft). The population is concentrated along the coast, where the main economic activity is fishing. Salt and copper mining, the cultivation of grains and fruits, and lumbering are also important to the economy, but almost no manufacturing takes place. The island has beautiful beaches and numerous shrines and temples. It is divided into four prefectures, and its largest cities are Kochi, Matsuyama, Takamatsu, and Tokushima.

Shiloh [shy'-loh] Located to the north of Jerusalem, Shiloh was an important city in early biblical times (*c.*1200–1050 BC). When the Israelites entered Canaan, they settled and headquartered the ARK OF THE COVENANT and the TABERNACLE at Shiloh.

Shiloh, Battle of The Battle of Shiloh, or Pittsburg Landing (Apr. 6–7, 1862), was a fierce clash of the U.S. CIVIL WAR in which Gen. Ulysses S. GRANT's 42,000-man Union army defeated the 40,000-man Confederate force led by Gen. Albert S. JOHNSTON. Grant, victorious at Fort Donelson, pushed along the Tennessee River to join Gen. Don Carlos BUELL's force of more than 20,000 and threaten the Confederate stronghold at Corinth, Miss. Johnston surprised Grant's troops, encamped near Shiloh Church in Pittsburg Landing, Tenn. Gen. William T. SHERMAN's forward camp was overrun, as were several other Union positions.

Johnston was killed during the savage fighting of the afternoon, and Gen. P. G. T. BEAUREGARD took command as a Confederate drive pushed Federals to the Tennessee River. Buell's arrival during the night allowed the Union to take the offensive and gain the final victory.

Shiloh was one of the most brutal battles of the war: Union casualties were more than 13,000; Confederate, more than 10,000. Strategic stalemate at Shiloh stabilized the Confederacy's western position.

Shimazaki Toson [shee-mah-zah'-kee toh-sohn] An important early-20th-century Japanese writer, Shimazaki Toson, b. Mar. 25, 1872, d. Aug. 22, 1943, first achieved recognition as a poet. He later wrote the first and probably the best Japanese example of naturalist fiction, *Hakai* (*The Broken Commandment*, 1906; Eng. trans., 1974). His subsequent novels are less socially conscious and more autobiographical in content, a trend that was soon taken up by other naturalist writers who strayed widely from their French models. Shimazaki's intimate identification with his heroes set a lasting precedent for 20th-century fiction in Japan.

shingles Shingles, or herpes zoster, is a viral infection of sensory nerve cells caused by the same virus (*Varicella zoster*) that causes CHICKEN POX. The virus remains latent in the dorsal root ganglia of the spinal cord after the initial attack of chicken pox. The disease occurs most frequently in people over age 50. In younger people it is often linked with a weakened immune system and can be an early indication of HIV infection. It may be activated through such factors as trauma to the spinal cord and its roots through surgery or X-ray therapy. Shingles is characterized by pain along an affected nerve and the eruption of blisters over skin areas supplied by the nerve. The only treatment is for symptoms.

Shinn, Everett [shin] The American realist painter Everett Shinn, b. Woodstown, N.J., Nov. 7, 1873, d. May 1, 1953, was a member of The Eight, or the Ashcan school, who exhibited in New York City in 1908. His early works reflect European styles of the mid-1800s, but, like others in the group, Shinn increasingly showed the influence of impressionism. Shinn loved nightlife and the theater and often painted gaslit theatrical scenes, sometimes with dramatically angled views of the audience in the semidarkness, as in *London Hippodrome* (1902; Art Institute of Chicago). Other works contrast affluent people with the poor inhabitants of refuse-filled streets.

Shinto [shin'-toh] Shinto is the indigenous religious tradition of Japan. Shinto has no historical founder; its roots lie deep in prehistoric religious practices. Nor does Shinto have any canon of sacred scriptures, although important elements of its mythology and cosmology may be found in ancient Japanese chronicles (the *Kojiki* and the *Nihonshoki*), and ritual prayers called *norito* were compiled into written collections at an early date.

The name *Shinto* is actually the Sino-Japanese reading for the more purely Japanese *kami no michi*, which means the "way of the kami." The *kami* are innumerable Japanese deities that may be thought of as full-fledged gods (such as the sun-goddess Amaterasu, from whom the imperial family is said to descend); the divinized souls of great persons (warriors, leaders, poets, scholars); the ancestral divinities of clans (*uji*); the spirits of specific places, often of natural beauty (woods, trees, springs, rocks, mountains); or, more abstractly, the forces of nature (fertility, growth, production).

Kami are generally worshiped at shrines (*jinja*), which are established in their honor and house the *go-shintai* (sacred objects) in which the *kami* are said to reside. Worshipers will pass under a sacred arch (*torii*), which helps demarcate the sacred area of the shrine. They will then purify themselves by washing their hands and rinsing their mouths, approach the shrine itself, make an offering, call on the deity, and utter a silent prayer. Special times for worship include important moments in the life cycle of individuals (birth, youth, marriage, and, more recently, school entrance examinations) and festival dates (*matsuris*) that reflect the rhythm of the year: the New Year, the advent of spring, rice planting, midsummer, harvesting, and so on. In addition, each shrine will usually have its own special *matsuri* particular to its own history or foundation. On any of these occasions the shrine will be crowded with worshipers, many of whom may wish to have their fortunes told or to receive special blessings or purifications from the Shinto priests.

The Kasuga Torii at Nara, Japan, constructed of painted cypress wood, reflects the formal simplicity characteristic of the sacred entranceways to Shinto shrines. An ancient religion native to Japan, Shinto integrates elements of folk religion with ceremonial rituals.

With the establishment of BUDDHISM in Japan during the Nara and Heian periods (AD 710–1185), Shinto quickly came under its influence as well as that of CONFUCIANISM and Chinese culture as a whole. On the one hand, it became more highly structured, following the Buddhist lead. On the other hand, certain *kami* came to be thought of as manifestations of particular Buddhas or bodhisattvas. (Amaterasu, for example, was identified with the cosmic Buddha Vairocana.) Thus the two religions both mixed and coexisted at the same time.

During the Tokugawa period (1603–1868), the Buddhist sects became tools of the feudal regime and neo-Confucianism served as the guiding ideology. Shinto was overshadowed in the process. Gradually, however, certain nationalist scholars, reacting against what they considered foreign ideologies, turned more and more to Shinto as the source of a uniquely Japanese identity.

With the Meiji Restoration in 1868—and the disestablishment of both the Tokugawa regime and the Buddhism that had accompanied it—Shinto naturally came to the fore. In the 1880s the government guaranteed freedom of religion to practitioners of all faiths but also drew a distinction between shrine Shinto (sometimes called state Shinto) and sect Shinto. The former was a nominally secular organization by means of which the state transformed shrines into centers of a patriotic and nationalistic "cult" applicable to followers of all faiths. Sect Shinto was a separate category for various popular religious groups (a total of 13 Shinto "denominations" were distinguished), which were thereby separated from the state-sponsored shrines and had to rely on private, nongovernmental support.

ship The word *ship*, from *scip* in Old English and Old Norse and *schiffe* in German, signifies any large waterborne vessel. In strict usage the word implies a vessel larger than a boat; custom among English-speaking people, however, has blurred the line dividing the two. Thus, fast mail and passenger steamers of considerable size are often referred to as packet boats, and, indeed, people other than professional sailors often refer to any passenger liner as a boat.

This article discusses the ship in various forms and during different periods. The earliest vessels (see also BOAT AND BOATING) are discussed briefly in the first section, which treats sailing ships and the history of their development. (Warships, mentioned here only briefly, are discussed in NAVAL VESSELS.) Materials, shapes, and nomenclature for the sails themselves are also dealt with here, and the section concludes with the rigging of sailing ships. Engine-powered ships are then discussed—first steamships and then more modern forms of propulsion, such as turbines, diesels, and nuclear power. A section on specialized types of ships treats air-cushion vehicles, OCEAN LINERS, TANKERS, hydrofoils, and cargo carriers. Related articles include NAVY and SHIPBUILDING. Separate articles treat many individual types of merchant and military vessels.

The Age of Sail

The earliest sailing craft were no more than flat rafts with a short mast set into position so that a single square sail could be hoisted. The *Kon-Tiki* is a balsa-wood replica of such an early craft on which the Norwegian explorer Thor HEYERDAHL and his companions crossed the Pacific in 1947. The oldest ship of which there is definite knowledge was built for the funeral of the pharaoh Cheops (3960–3908 BC). Found near his tomb in a trench and covered with sand, this ship was an open-hulled vessel (that is, it had no deck) 40 m (133 ft) in length, with a maximum beam of 8 m (26 ft). It was probably used only for Cheops's funeral and neither went to sea nor floated on the Nile. Much evidence exists, however, that the Egyptians employed similar ships for trading on the Mediterranean.

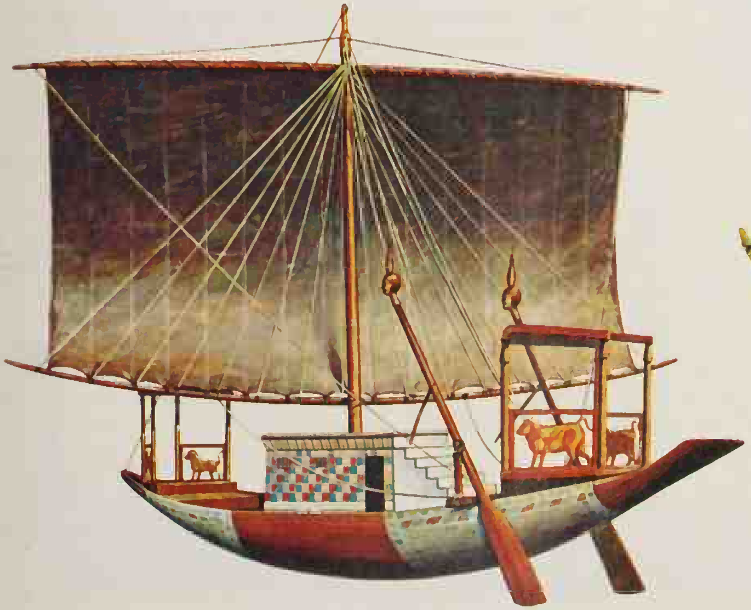
Similar sources also indicate that, although such ships were normally propelled by oars manned by slaves, the Egyptians also harnessed the natural power of the wind by hoisting a square (more accurately, rectangular) sail. Such a ship was steered by an extralarge oar slung over one quarter for which the word *steerboard* was coined—hence the term *starboard* for the right side of a ship.

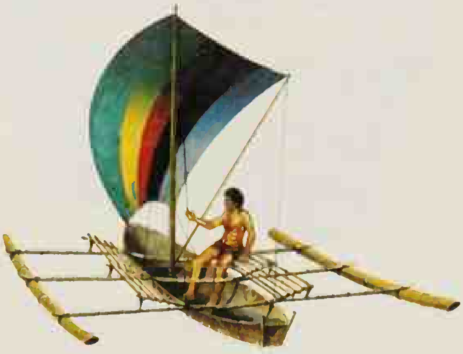
Phoenician, Greek, and Roman Ships. The Phoenicians, who ruled much of the Mediterranean from about 1000 to 250 BC, improved on the Egyptian design. They built similar vessels (see GALLEY) of approximately 30 m (100 ft) in length, with which to trade on the Mediterranean, and larger Tarshish ships with which they ventured out through the Straits of Gibraltar.

By this date the basic principles for building the hull of the type of ship used in European waters had been developed. The frame comprised a longitudinal keel (backbone), with stemposts and sternposts, and athwartship ribs. This structure was transformed into a watertight vessel by covering it with a skin of wooden planks coated with pitch.

Because they were so broad-beamed, or wide, such trading vessels were known as "round ships." The Greeks increased their size. The Romans introduced the idea of partly decking their ships to provide passengers and crew with shelter from the elements.

Chinese and Middle-Eastern Ships. In the Far East the





Two early forms of sailing craft are the double outrigger canoe (above), developed for ocean travel in the South Pacific islands, and the round-hulled Egyptian sailboat (left). The lightweight outrigger, a dugout canoe balanced by wood or bamboo floats, can attain great speeds on smooth seas. The Egyptian sailboat, first used on the Nile and later on the Mediterranean, was developed from boats originally made of reeds. This ship (c.2000 BC) was steered by enormous oars located about the stern quarter.

Chinese evolved a different design of vessel, the JUNK. They joined together two dugout CANOES, using planking, and then built up the sides, bow, and stern to form a flat-bottomed wooden box, that is, a hull without a keel. A wedge-shaped addition provided this box with a bow. Its stern was built up so that it would remain dry in a following sea. Inside, on the center line, a second, vertical, watertight box contained the steering oar.

Most innovative of the Chinese maritime innovations were their lug sails, stiffened with full-length battens and controlled ingeniously to shorten sail like a Venetian blind or to sail into the wind like a modern racing yacht.

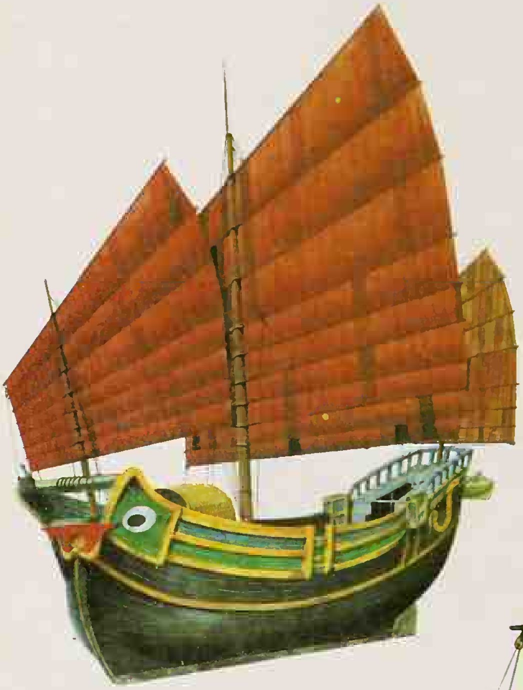
The Japanese, Javanese, and other Eastern civilizations built their own forms of the junk. With their many variations, these craft were superior to any Western vessels built before the 17th century. The small variation of the junk, the sampan, often is used today with an outboard motor as a power adjunct.

The steady winds of the northeast monsoons created a special situation in the Indian Ocean, and the Arabs, Persians, and Indians devised a lateen-rigged type of vessel that was well suited to it. The triangular-sailed dhows that ply the Red Sea and the Indian Ocean today are thought to be little different from those of 2,000 years ago. The Egyptian felucca, used on the Nile River, is an adaptation of the dhow.

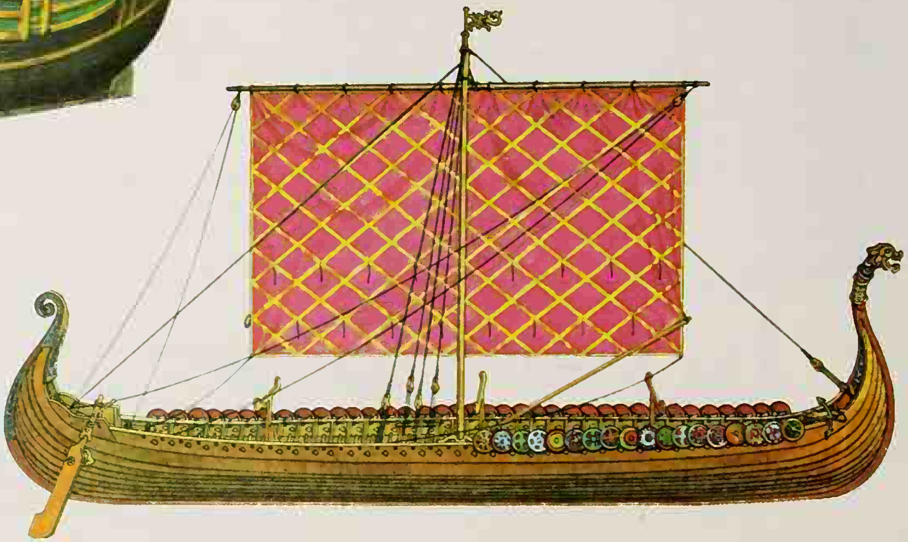
Early European Ships. The 7th century AD brought a new era in European ship design. From remains such as the Nydam boat found near Flensburg in Holland in 1863 and the vessel discovered more recently in the SUTTON HOO SHIP BURIAL in England, it is known that the vessels with which the Vikings carried out their overseas raids were long and narrow, and of shallow draft. Sometimes propelled by oars, they were more usually driven by a single, large, square sail. A century later these Viking longships, such as the one whose remains were found in the Gokstad ship burial in Norway in 1880, were around 25 m (80 ft) in length.

By this time, sail was replacing the oar as the prime means of ship propulsion. The invention, in the 12th century, of the rudder to replace the steerboard greatly facilitated steering, enabling seamen to learn that by bracing their ships' sails at a sharp angle to the fore-and-aft line, they could set a course close-hauled, that is, about 45 degrees off the direction of the wind. These developments were followed by an increase in the number of masts and sails (especially the latter) when it was discovered that several small sails could be more easily handled by a ship's crew than a single large one.

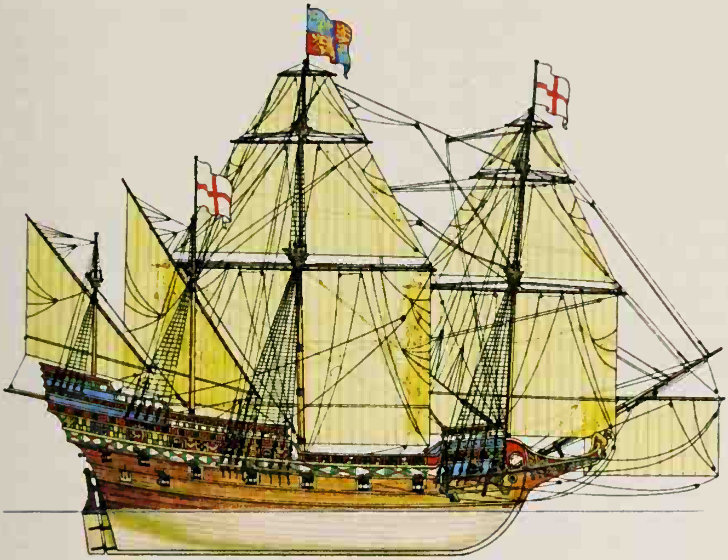
In the 13th century the most common type of ship in northern European waters was the single-masted cog, with a broad beam and deep draft that gave it a considerable cargo-carrying capacity. The more advanced countries bordering on the calmer waters of the Mediterranean



(Above) *The Chinese junk, a highly efficient sailing vessel of ancient origin, features a strongly reinforced hull with a high stern and a massive steering rudder. Its trapezoidal sails are stiffened with wood or bamboo battens.*



(Right) *A double-ended Viking longship (AD c.800), with its pronounced keel, broad, shallow hull, and oarlike rudder, was tailored for ocean travel. Its single sail was reinforced with leather strips.*



The galleon, a warship derived from the carrack, originated during the mid-16th century and was most fully developed by the British. Its low prow design produced greater maneuverability and increased its stability when armed. The forecastle, originally designed to facilitate the boarding of enemy vessels during combat, was lowered, the sterncastle raised, a fourth mast, the bonadventure mizzen, added, and numerous guns mounted broadside. The introduction of heavy artillery on board ship revolutionized naval warfare, which had previously relied on boarding and hand-to-hand combat in battle.

evolved the two-decked, finer-lined caravel. Initially lateen rigged on two masts, the caravel soon stepped three masts—foremast, mainmast, and mizzenmast—with square sails on the forward two and a lateen sail on the third.

Ships in the Age of Exploration. The great discoveries of the 15th and 16th centuries, by such men as Bartolomeu DIAS, Ferdinand MAGELLAN, and Christopher COLUMBUS, were all made in caravels. Unhappily, none has been preserved for posterity, but full-sized replicas of Columbus's *Santa María* have been built in recent years.

With the opening of all-sea routes from Europe around the Cape of Good Hope to the Far East, and across the Atlantic to the New World in the west, came a great increase in seaborne trade. Spain led the way to larger merchant ships by designing and building carracks of as much as 1,600 tonnage. These and the later GALLEONS were the forerunners of the full-rigged ships.

Ships of the 17th and 18th Centuries. The caravel-built sailing ships of the 17th and 18th centuries—notably those of the British and Dutch EAST INDIA COMPANIES, which had been established to obtain and bring to Europe the valuable products of the East Indies—were the epitome of the shipbuilder's art until, in the 19th century, wooden hulls were superseded by iron (and, later, by steel). Known as East Indiamen, some of these ships were more than 60 m (200 ft) long, more than 15 m (50 ft) in breadth, and of greater than 2,000 tonnage, with up to five decks.

All these ships were armed, after the manner of warships, for protection against privateers (warships of other nations) and pirates. None of these splendid ships has survived.

Merchant ships similar to East Indiamen were used for bringing to Europe the products, notably sugar, of the West Indian islands colonized by Britain and France. Smaller vessels, however, were built for coastal and inshore trading.

19th-Century Ships. In the 19th century the need for larger ships with a greater cargo capacity—necessary both for the Chilean nitrate trade and for the Australia run, where emigrants were taken to Australia and wool brought back to Europe—produced larger vessels carrying from four to seven masts. Similarly, the demand for faster ships—in the United States for carrying prospectors from the east coast to the goldfields of California and Australia, in Britain for the China tea trade—led to the design of the slender, square-rigged craft known as CLIPPER SHIPS.

Dreadnaught was one of the most consistently fast clippers. Donald MCKAY's clipper *Great Republic* was (at 4,555 tons) the largest wooden ship ever built.

Clipper ships and packet boats—speedy, slim-lined sailing ships that ran regular routes between Europe, the Americas, and China, carrying mail, official government cargoes, and such special passengers as ambassadors—were the fastest ships of their time, but their carrying capacity was necessarily restricted by their fine, sharp lines and their V-bottom hulls. Nevertheless, the British tea trade placed such a high premium on speed that the clipper-ship era lasted long after dependable, but slower, steamships were available.

In the 20th century mechanical propulsion almost entirely replaced sail, except in the Far East where junks are still widely used. By 1934 only 40 square-rigged sailing ships remained afloat, 16 of these being used by various countries for training purposes. Today only about 20 large sailing ships remain in service worldwide.

The Yacht. The one notable exception to the demise of the sailing ship is the yacht, a sailing vessel used for both pleasure and racing purposes. Yachting proliferated worldwide, especially after World War II. Even so, yachts such as those which compete for the America's

Cup are smaller than the famous "J" class of the 1920s and '30s.

Sails and Rigging

In the 19th-century heyday of sailing ships, strict maritime usage limited the appellation *ship* to square-rigged vessels only—those with three or more masts, each with a topgallant mast, and each crossed by at least five yards, the spars that held the great square sails that gave the ship her power and her singular beauty. Supporting and controlling sails and masts, hundreds of separate lines, cables, ropes, spars, blocks, tackles, and lifts were organized into a system of enormous complexity, but one that any sailor knew as well as the palm of his hand. Along with parts of the body of the ship itself, each mast, sail, cable, spar, and rope had its name, and thus nautical nomenclature is among the largest and richest of any technology.

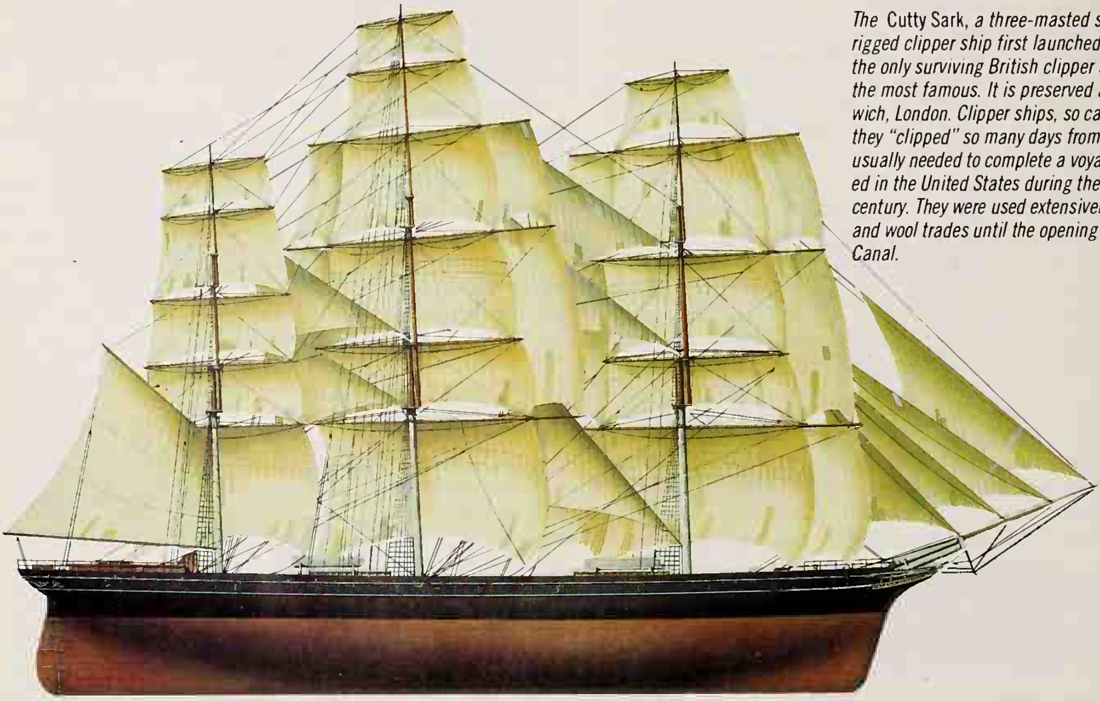
Limitations in the available materials, of course, influenced the design and size of almost every part of the ship. Trees that were large, straight, and strong enough to make a complete mast were rare. Hence the mainmast ended in an iron and timber structure, the top, on which was mounted the topmast. The topmast in turn supported the topgallant mast, which could be lowered and replaced, if necessary, even at sea. The top-most mast—used only on the largest ships—was called the royal. The great square sails hung in ordered procession—as many as five or six each for foremast, main mast, and mizzenmast—across each mast. Each sail was suspended from its yard.

Each square sail had its name: mainsail, topsail, topgallant sail, royal, skysail, and moonsail—each smaller as one looked upward. The sails were further identified according to the mast on which they were set (mizzen royal, main royal). There were special names for a few: the crossjack, or "crojack," was the lower square sail on the mizzenmast, and the corresponding sail on the foremast was the foresail, or forecourse.

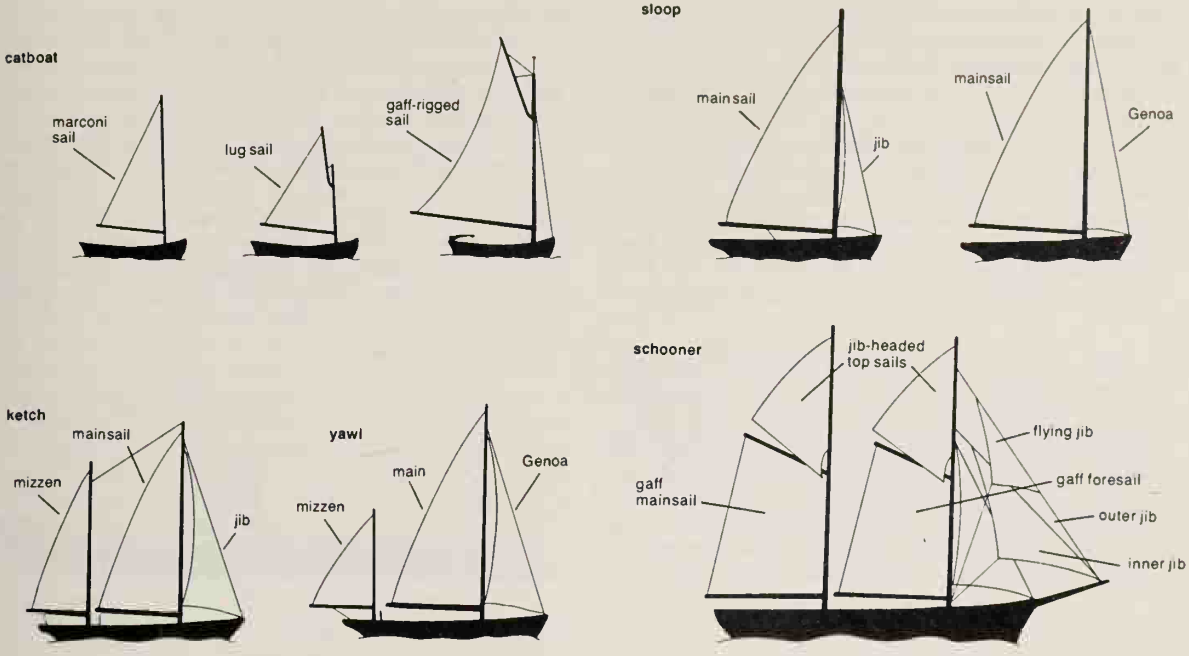
The distinction between square sails and fore-and-aft sails is an important one. Early fore-and-aft sails, usually triangular in shape, were hung abaft the mast (that is, in the direction of the length of the ship; square sails hung athwart, or across the width of the ship) on gaffs that were suspended at an angle from the mast. Fore-and-aft ships generally carried only two sails per mast. Fore-and-aft schooners, and ships that used combinations of fore-and-aft and square sails—the brigantine, barquentine, and topsail schooner—did not require large crews to handle their relatively fewer sails. Although they were often slower than the square-riggers, they were easier to operate, and because they could sail closer to the wind, they were handier for coastal voyages. The square-riggers used the steadier trade winds and plotted their routes to make the most of them.

Modern sailboats still use these fore-and-aft sails and have kept their names: staysail, jib, and spanker, among many others.

Around the world sails had been made from papyrus, palm leaves, straw matting stiffened with bamboo strips, animal skins, and canvas woven of flax. Flax sails were on all the great explorers' ships. By the time the sailing ship



The Cutty Sark, *a three-masted square-rigged clipper ship first launched in 1869, is the only surviving British clipper and one of the most famous. It is preserved at Greenwich, London. Clipper ships, so called because they "clipped" so many days from the time usually needed to complete a voyage, originated in the United States during the mid-19th century. They were used extensively in the tea and wool trades until the opening of the Suez Canal.*



Five basic types of sailboat illustrate some of the many variations of rigging. The three versions of the catboat (top, left) *carry an easy-to-rig marconi sail, a small lug sail, and the large gaff-rigged sail often seen on older boats of this type. The two sloops* (top, right) *may change their jibsails to match different wind conditions. The ketch* (bottom, left) *has a larger mizzen and—like most small boats—a rear-mounted rudder. The yawl* (bottom, center) *is distinguished by its small mizzenmast, located behind the tiller. Largest of these boats is the schooner* (bottom, right), *whose two tall masts and bowsprit—the spar extending from the ship's stem—allow for a wide variety of rigging.*

reached its technological apex, however, most sails were made of cotton.

The rigging that held the masts and controlled the sails in the age of great sailing ships—and still does today on all sail-equipped vessels—was divided into two main types: standing rigging and running rigging.

Generally speaking, standing rigging was more or less permanently in place, holding the masts and sometimes the bowsprit, the large spar projecting over the bow of a vessel. Rope shrouds supported the masts on each side (with cross ropes called ratlines, by which the crew could climb), and stays held the masts fore and aft. When standing rigging was made of rope it tended to stretch and shrink, depending on the strains put upon it, the wetness or dryness of the weather, and the materials from which it was made. To tighten the shrouds, sailors used wooden blocks called deadeyes. A pair of deadeyes, rigged with lanyards, could be hauled tight, or "set up," to tighten the shrouds. Later, when iron and steel wire rigging was manufactured, turnbuckles or rigging screws proved to be an infinitely more efficient system.

Running rigging controls the smaller spars and the sails. Halyards ("haul yards") were originally used to lift the yard. On today's sailboats they hoist the sails. Downhauls and lifts do what their names suggest. A buntline is a rope used to pull up the bottom of a topsail, thus spilling the wind the sail is holding. A furling, or gasket, line wraps around a furled sail, tying it to its mast or yard. Reefing halyards were used to rotate the yard, rolling the sail around it and reefing (shortening) it. A square sail—and modern conventional sails—use reef points, short ropes attached along the sail's width to tie it to the yard or boom when reefing it.

Engine-Powered Ships

The attempt to use a STEAM ENGINE to propel a ship had been made almost since James WATT, in 1774, began manufacturing his first engines. It was the invention (1802) by the Scottish engineer William Symington (1763–1831) of the crank and connecting rod—which converted the back-and-forth motion of the engine's piston rod into a rotary motion that could rotate a paddle wheel—that first made steam propulsion a practical means of powering waterborne craft. In 1807, Robert FULTON installed a Boulton and Watt steam engine in his 45-m (150-ft) vessel, the *Clermont*.

Fulton's was the first successful steamboat. The paddle-wheeled ships that followed Fulton's prototype were capable of both speed and maneuverability and were well suited to river and bay transport. Paddle wheels, however, were a disadvantage in the rough waters of the oceans.

The age of the steamship was slow in coming. Shipbuilders continued to include a full complement of masts, spars, and sails. The U.S. ship SAVANNAH, the first steamship to cross the Atlantic (1819), had a dozen sails—they were used, in fact, far more than the steam engine, which operated for only 80 hours in a voyage of 27 days. The British ship *Sirius* was the first to cross the Atlantic entirely under steam power (1838), although she ran short of fuel en route and was reduced to burning her spars and furniture.

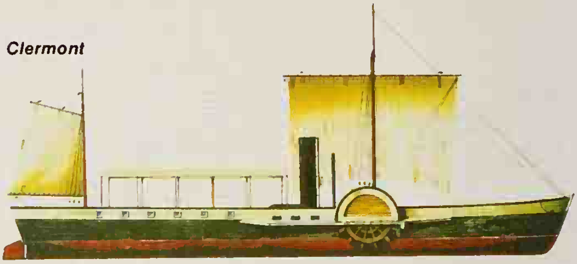
The maiden voyage of the *Great Western* was made the same year. A wooden ship of 72 m (236 ft) in length—considerably longer than most oceangoing ships of the time—with four boilers providing steam for her paddle wheels, it made the Bristol–New York run in 15 days, at an average speed of 8 knots (14.8 km/h; 9.2 mph). The *Great Western* became the first steamer in regular transatlantic service and inspired Sir Samuel CUNARD to inaugurate his shipping line, beginning, in 1840, with wooden paddle steamers that made the twice-monthly Liverpool-Boston voyage in an average of 15 days. Cunard's lead was soon followed by other shipping lines.

The *Great Western* had been the engineering creation of Isambard Kingdom Brunel (see BRUNEL family), the most important ship designer of his day. Brunel's *Great Britain* (1843) was the world's first large iron ship and the first to use a screw propeller.

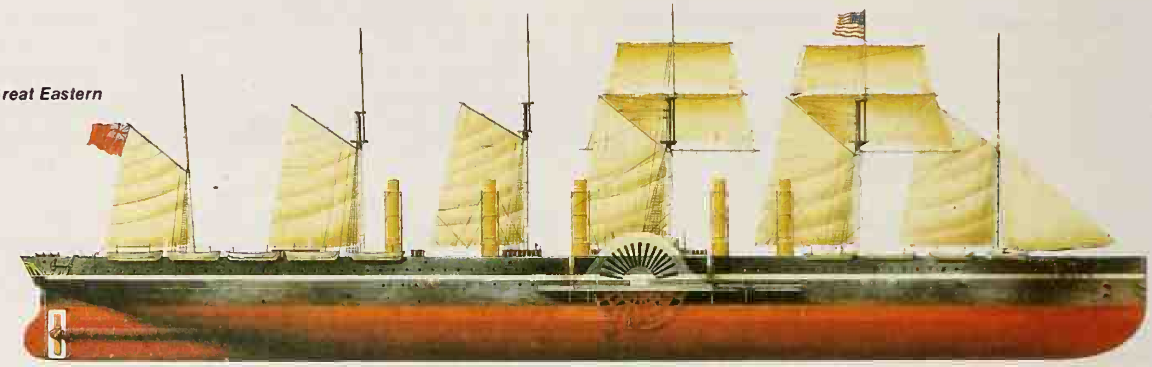
Screw Propellers. The principle of the Archimedes screw was common knowledge, but only in the 1830s

The steamship Clermont, *launched in 1807 by Robert Fulton, demonstrated the economic practicality of steam navigation. The ship provided passenger service along New York's Hudson River until its retirement in 1814. When launched in 1858, Isambard K. Brunel's* Great Eastern *was the largest ship afloat and was powered by a combination of sails, paddles, and propellers. It was a commercial failure as a passenger-cargo carrier. The British* Lusitania, *one of the first liners powered by steam turbines, shared speed records for transatlantic crossings with its sister ship, the* Mauretania. *In 1915 the vessel was torpedoed by a German submarine and sank with a great loss of life, a provocation that led to U.S. entry into World War I.*

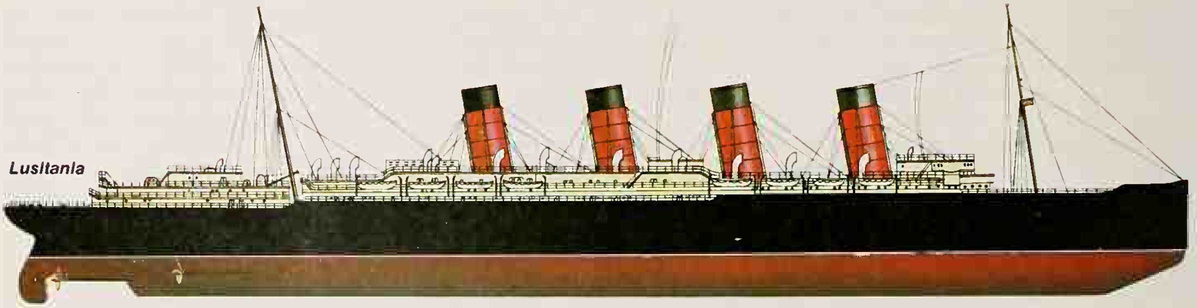
Clermont



Great Eastern

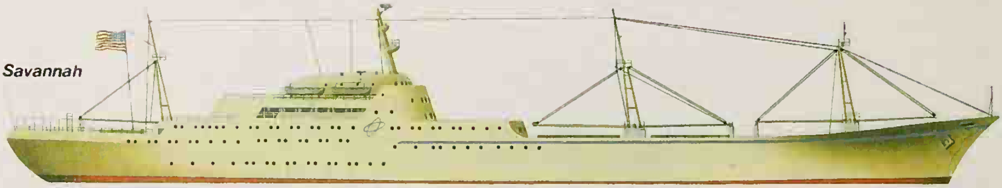


Lusitania



The Savannah, launched in 1959 as the first nuclear-powered merchant vessel, was built by the U.S. government to demonstrate the peaceful applications of atomic energy.

Savannah



were attempts first made to apply it to ship propulsion. The Frenchman Frederic Sauvage, the Swede John ERICSSON, and two Englishmen—Robert Wilson and Francis Pettit Smith—all contributed to its invention, although Smith was awarded the patent. Within a few years, improvements in propeller design were in use on steamships and naval vessels built throughout Europe and the United States.

The first propellers consisted of two very thin blades, resembling those of an aircraft propeller; soon, however, three-bladed, four-bladed, and eventually multibladed propellers of increasingly sophisticated design were in use. The increasing horsepower of the engines added to the capabilities of the propellers; soon ships carried several engines, with each engine driving its own propeller, adding thrust, speed, and maneuverability.

Brunel's third ship, the GREAT EASTERN, was launched in 1858; 211 m (692 ft) long, and displacing 27,400 tons, it carried a crew of 400 and 4,000 passengers and remained the largest ship in the world until the end of the 19th century.

During the next 20 years, as paddle wheels were superseded by screw propellers, marine engines also steadily improved. Engines became more powerful and sophisticated. Most were compound engines of various kinds, in which the steam was used first in a high-pressure cylinder and then in one or more low-pressure cylinders. New BOILER designs were capable of generating steam at ever higher pressures.

Turbines. Just at the point where it seemed that no further improvements could be made in piston steam engines, the steam TURBINE began to make significant inroads in ship propulsion. The work of the English engineer Sir Charles Algernon Parsons was particularly important. After inventing (1884) a turbine-driven dynamo, he turned his attention to the powering of ship-propulsion systems. His first turbine-propelled vessel, the *Turbinia*, made such an impression at the Royal Fleet Review in 1897 that his propulsion system was rapidly adopted for small warships, such as destroyers, and for increasingly larger ships until, with its installation (1905) in the *Dreadnought*, a revolutionary new battleship, it became the form of propulsion for all warships. The first turbine-powered merchant ship (1901) was a small British packet boat, *King Edward*, which ran in the Firth of Clyde in Scotland and attained a speed of 20 knots (37 km/h; 23 mph). The Cunard *Carmania* was the first liner to install a steam turbine (1904). The famous Cunarders LUSITANIA and *Mauritania* (the latter, for almost a quarter century, was the fastest ship on the Atlantic) were equipped with Parsons turbines, as were most transatlantic liners as the 20th century progressed.

During the coal-fired era, the steam turbine was preeminent for driving a high-speed ship, but it was not as economical as the triple-expansion reciprocating engine. The advent of oil as a fuel eventually transformed this situation. Rudolf Diesel had patented his DIESEL ENGINE in 1892.

Well into the opening years of the 20th century, the two eras of maritime history overlapped. The shoreline of any great port city still showed a mixture of tall masts and crossed yardarms with the smokestacks and funnels of steamships. Powered versions of almost every type of vessel were now in use. Some, such as the towboat and harbor tug, existed only in powered form. Curiously, the steam tugboat had helped the sailing ship survive into the 20th century, enabling her to move in and out of the slips, piers, and docks of modernized harbors without the necessity of maneuvering to take advantage of the wind or compensate for tidal currents. In addition, the skill of a sailor was still measured by his knowledge of sailing.

By the third decade of the 20th century, however, the sailing vessel had vanished from the fleets of western commercial ships (although they continue to be used—especially in conjunction with engines—throughout Asia and Africa).

New Power Systems. Whereas conventional steam-turbine installations with oil-fired boilers—or, alternatively, multicylinder diesel engines—are the propulsion systems in universal use for merchant ships, two new power systems have been introduced for warships—nuclear power and the gas turbine. Nuclear-powered vessels use nuclear reactors to provide the heat to raise steam to drive turbines. The gas turbine is a self-contained unit driving the propeller shaft through reduction gearing; it requires little supervision, is small and light, and has a very short start-up time.

Nuclear power has the advantage of providing power for long periods and for millions of kilometers of high-speed steaming without the need to replenish its fuel (the core of the reactor).

The high cost of nuclear-power systems and the reluctance of some nations to allow nuclear-powered ships in commercial docks have inhibited the application of nuclear power to cargo-carrying merchant ships.

Gas turbines, too, are not economically suitable for merchant ships and are confined to small warships. Such ships may be equipped either with a system combining steam and gas turbines, the latter being used to boost the former for full speed and to provide instantly available power at all times, or with a large and powerful gas turbine for full power and smaller ones for economical cruising speeds.

Although petroleum is still the main source of ship's fuel, its high cost has encouraged the tentative and experimental return of the sail on freighters and fishing boats, which use them as auxiliaries to their usual propulsion systems.

Specialized Types of Ships

During the first half of the 20th century the great passenger liners dominated the ocean routes. The great expansion of air travel after World War II, however, dethroned the liners almost overnight—just as the time for transatlantic ship passage was cut (1952) to 3 days, 10 hr, 40 min by the S.S. *United States*. Within two decades, most of the liners were out of service; those which remained were used as cruise ships or were docked as floating museums (for example, the R.M.S. *Queen Mary* at Long Beach, Calif.). The last liner to be built, Cunard's QUEEN ELIZABETH

II (1968), was smaller and slower than many of her predecessors. She now serves primarily as a cruise ship.

Cargo Ships. A number of types of cargo carriers also plied the oceans, varying between the cargo liners of the more prestigious companies and the tramp steamers finding their cargoes wherever they were offered. For mixed cargoes the most usual type was the "three island," in which the "islands" were the raised poop, midships bridge superstructure, and forecastle. Homogeneous bulk cargo, such as grain, mineral ores, coal or oil, required other designs.

The "turret" and "trunk" ships carried grain and ore. TANKERS for transporting crude oil made their first appearance in 1885. These cargo ships required special features such as the cofferdams separating the tanks from other spaces to prevent leakage from one to the other, expansion trunks, mechanical venting, and steam heating to reduce oil viscosity in cold weather. They could maintain fore-and-aft trim by filling empty tanks with water; therefore, the machinery could be situated aft and the propeller shafts could be shortened. As the problem of trim became resolved in other types of ships, they, too, introduced this feature. Even some passenger liners have the machinery aft, so today the silhouette of a general cargo ship may differ from that of a bulk cargo carrier only in the type and amount of cargo-handling equipment.

Even this distinction is disappearing today because of the development of two new types of general cargo carriers: the "roll-on, roll-off" (Ro-Ro) ships, in which cargoes in special containers are passed over ramps through doors in the ships' sides; and container ships, in which standard containers, often filled at factories far from the loading port, are hoisted on board by special loading systems and stacked in cellular holds and on deck.

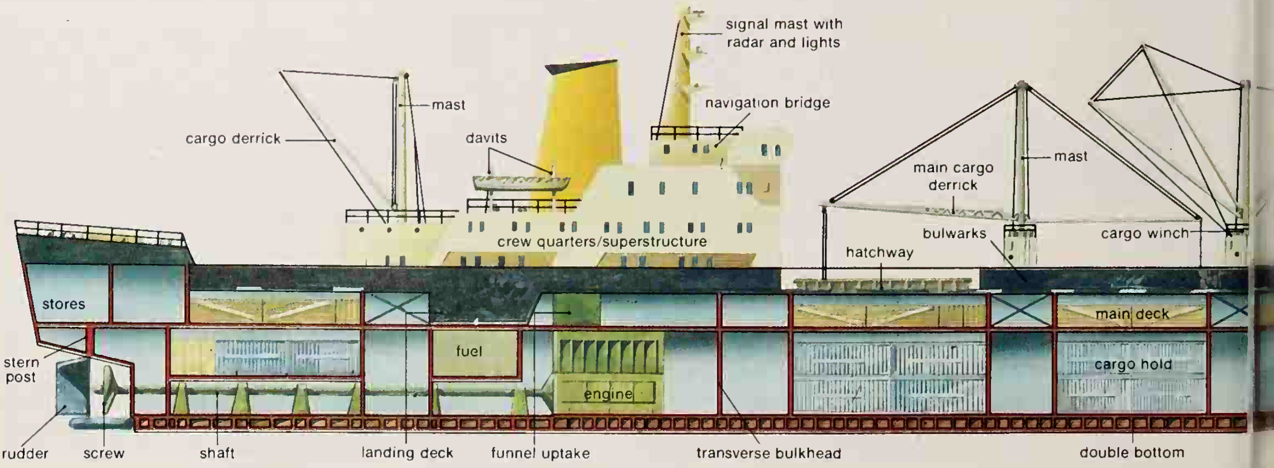
Tankers have meanwhile grown out of all recognition from the 12,000-ton, 15-knot ships built by the British to replace the great number lost during World War II, or the 16,800-ton, 16-knot standard U.S. tankers built at the same time. Ships of 24,900 tons deadweight, called supertankers, were first built in 1949. When the Suez Canal was closed in 1956 and again in 1967, the shortest route for Middle Eastern oil to Europe was blocked, and it became necessary to sail around the Cape of Good Hope. To make this economical, even larger tankers were required. The first to take advantage of the need for these larger tankers were the Japanese shipyards, which were redesigned to build supertankers of 100,000 tons, and then even larger ships of 250,000 to 275,000 tons, known as very large crude carriers (VLCC). The economic success and reasonably safe operation of these enormous ships led to even larger vessels, the ultralarge crude carriers (ULCC) of tonnages up to 400,000, while others up to double that size are in the planning stage.

Although economic considerations suggest such huge ships, the safety factor causes concern among many in the shipping world. The supertankers require many kilometers to stop and are not very maneuverable. When routed through narrow and perhaps foggy seaways like the English Channel, they pose a high risk to other shipping, and damage from grounding or collision can result in oil spills of enormous proportions. They also share with all tankers, but on a greater scale, the risk of gas explosion in emptied tanks.

Among the smaller commercial craft of special design are the tugboats, also called towboats. In relation to their size, these craft use powerful engines, but their very large, slowly rotating propellers are the secret of tugboat thrust.

Fishing boats have evolved into a number of different types according to the kind of sea, type of catch, and necessary length of the voyage (see FISHING INDUSTRY).

New Types of Water Craft. Two types of craft that can be said to have now advanced from the status of "boat" to that of "ship" are the hovercraft (see AIR-CUSHION VEHICLE) and the HYDROFOIL. Examples of each type of about 230 tons are in service. A hovercraft rides above the surface of the water (or land, for that matter) on a cushion of air provided by fans and is propelled by air screws (propellers). The hydrofoil has been under development since the early 20th century, but it was not until 1956 that the first hydrofoil went into operation between Sicily and Italy.



shipbuilding The term *shipbuilding* usually refers to the actual construction of a ship. The design stage that precedes shipbuilding is performed by a naval architect, and the science of ship design is called naval architecture. The specialty dealing with power plants used in ships is known as marine engineering.

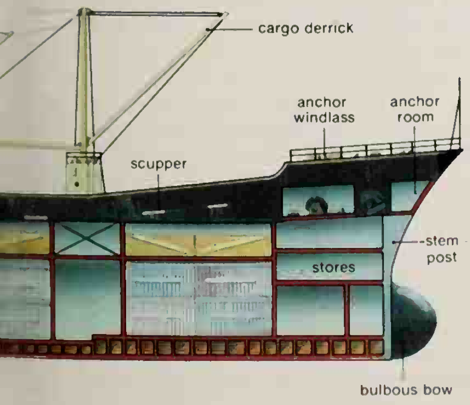
Historical Perspective

The typical wooden ship was constructed in a shipyard, on a *building ways* under the supervision of a master shipwright. Near this building ways the ship's timbers, planks, and masts were cut and shaped from seasoned logs. The wooden parts were fabricated piece by piece and then fastened together on the building ways. First, a massive keel (the lowest, principal timber of the ship) was laid on timber blocks. Stemposts and sternposts were fastened to the keel. The frames, which defined the form of the hull, were constructed beginning amidships (in the middle) and then proceeding toward both ends. When the frames were in place, a strengthening structure of timbers called the keelson was laid over the intersection of the keel and the frames.

Once the ship's skeleton was complete, the hull planking and decks were attached. When the hull was complete, a cradle was built under it, and hull and cradle together were slid down the building ways and into the water. The hull was then towed to an outfitting pier, for the remaining work.

Most shipyards were relatively small during the age of wooden ships. The few large shipyards, however, were probably responsible for such innovations as DRY DOCKS, builders' models, heavy lift cranes, standard designs, stockpiling of common parts, and the series production of identical hulls.

Since about 1940 the construction of both commercial and NAVAL VESSELS has changed in several dramatic ways. These changes may, in part, be attributed to the development of new steels, the use of welded instead of riveted connections, the increased use of aluminum, the advent of computer-aided technology, construction orders for several identical ships, and, above all, the need to improve productivity.



The diagram of a modern oceangoing cargo ship indicates several major operational features. Although the ship is larger and more sophisticated than its predecessors, its basic design—with the main cargo holds placed forward of the engines and bridge area—is similar to those used in cargo vessels since the late 19th century.

Modern Shipbuilding

A modern shipyard is predominantly an assembly facility. As soon as the specifications and contract plans have been agreed upon, the naval architects, engineers, and drafters develop the necessary working drawings and assembly instructions.

Because the ship is invariably constructed according to the rules of a classification society, many of these plans must be submitted to the society for approval. Several federal agencies and a few international organizations are also involved in determining the suitability of ship designs.

The efficient flow of structural material is essential for a modern shipyard. Flat plates and shapes are delivered to a storage yard from the steel mills. When a particular size plate or shape is needed, it can be lifted by magnetic pickups slung from an overhead crane and moved onto a conveyor system, which moves the steel through a shot-blasting facility for the removal of scale and rust and then into a painting and marking shop for the application of a primer coat and the proper identifying marks. Next the prepared material is accurately cut to the required shape by automatic burning machines. When bending is required, powerful plate presses or frame benders may be used. The various pieces are then brought to a welding shop where the flat plates and shapes are assembled. The structural members are positioned by manual or remotely controlled equipment. Routine welding is performed by automatic welding machines.

Subassemblies are joined together to form still larger modules, which in turn form major sections of the hull. These modules are then moved by large overhead cranes to various outfitting areas. After as much of the outfitting as possible has been completed, the modules are moved by gantry crane to the building dock or final assembly area and are joined together to form a nearly complete ship. Because of the accuracy of computer-aided design, cutting, and fabrication, the structural members and internal equipment of adjacent modules generally align very well. The long seams are then welded together mechanically.

Launching may be performed by a variety of methods: directly from a building ways, from a floating dry dock, or from a building dock that is flooded until the ship floats. After the ship has been launched, it is towed to an outfitting pier, where the propulsion plant, electrical generation system, piping, and steering gear are installed and checked. The ship then puts to sea for a series of speed tests and maneuvering trials.

shipping Shipping is the industry that moves goods around the world by water. Today's major shipping nations transport millions of tons of cargo worth billions of dollars in import and export revenues each year. The Panamanian merchant fleet is the world's largest, with more than 3,500 vessels registered in that country—although most of the ships actually belong to other nations; such an arrangement is called a flag of convenience. The USSR ranks second, with about 2,500 vessels. Other large fleets include those of Liberia (also a flag of convenience), Greece, and Japan.

The U.S. merchant fleet, until just a few decades ago one of the most prominent in the world, now holds a minor ranking. In 1981 only 578 U.S. vessels, or 2.3% of the world total, were active; by 1983, the total had declined even further, to 469. In the late 1980s, however, the fleet had begun to expand slowly, to almost 750 vessels.

The decline of the U.S.-flag merchant fleet over the past 30 years can be attributed to several political and economic factors. Assisted by the large-scale sale of World War II ships by the United States, foreign nations rapidly built up their own merchant fleets. The rapid emergence of state-controlled carriers, which often operate below cost to compete for cargo, has eroded commercial carriers' positions on many trade routes. Significant differences in labor costs have given foreign ships a competitive edge. Finally, the lack of a comprehensive national maritime policy in the United States has hindered maritime growth.

Major Cargoes. The ability to transport cargo in vast quantities has made oceanborne shipping the dominant means of world transportation. (Air freight accounts for about 5% of the carriage of world trade.) Generally, there are two main types of cargo important to world shipping: bulk commodities and manufactured goods. The most important bulk commodities are grain products, such as wheat, corn, and soybeans, and energy-related raw materials including coal and petroleum. Major manufactured goods carried include automobiles, industrial machinery, and electronic products.

Grain is hauled in dry bulk carriers that can be loaded or unloaded rapidly at pierside grain elevators. Huge oil TANKERS, some of which weigh more than 200,000 tons, use tanks designed specifically for petroleum transport. Coal is shipped via dry bulk carriers known as colliers, as well as on ships designed to accommodate loaded BARGES, which are known as LASH (Lighter Aboard Ship) vessels.

Manufactured goods are usually placed into large containers and transported in containerized vessels in the liner trade, a shipping service that makes frequent calls at various world ports on a regularly scheduled basis.

Inland Shipping. The major inland waterway systems in the United States and Canada comprise more than 41,850 km (26,000 mi) of navigable rivers, CANALS, lakes, and coastal regions. Of these, the two largest are the MISSISSIPPI RIVER system, through the center of the United States; and the Atlantic Coastway system, which follows the Atlantic coast from Bangor, Maine, to Miami, Fla. The ST. LAWRENCE SEAWAY extends from the Atlantic Ocean at the province of Quebec, through the St. Lawrence River into the Great Lakes.

Probably one of the best known European systems is the Rhine River, which originates in eastern Switzerland and flows northward 1,320 km (820 mi) through Germany and the Netherlands into the North Sea.

The primary method of transporting bulk goods through inland water systems is by tow barge. As many as 60 steel, low-draft barges may be lashed together with steel cable and pushed by a towboat at speeds of up to 19 km/h (12 mph). The inland barge industry offers a very economical means to move cargo.

See also: INTERNATIONAL TRADE; MARITIME LAW; SHIP.

shipworm Shipworms, genus *Teredo*, family Teredinidae, are wood-boring marine bivalve mollusks. They have wormlike bodies and disproportionately large siphons. The shell valves, reduced to two small anterior valves with filelike ribs, are specialized for boring by means of alternating contractions of anterior and posterior adductor muscles, implemented by a dorsal and ventral ball joint between the valves. Shipworms digest the cellulose of wood and have caused great damage to dams, docks, and the bottoms of boats.

Shiraz [shee-rahz'] Shiraz, capital of the province of Fars, southwestern Iran, lies in a fold of the Zagros Mountains. It has a population of 848,289 (1986). Shiraz is famous as a cultural center. Cement, sugar, fertilizers, textiles, and handicrafts (especially carpets and mosaics) are manufactured. The city was the birthplace of the poets Mohammed Shamsoddin HAFEZ and Sheykh Moslehoddin Sadi, whose superb garden tombs are on the northern edge of the city. Among the city's many fine buildings are mosques from the 9th and 13th centuries. The ancient site of PERSEPOLIS is to the northeast.

Shiraz became an important center as early as the 4th century BC, but it attained its greatest prestige as an Islamic cultural center from the late 7th century AD on. It was the capital of the Zand dynasty (1750–94).

Shirley, William William Shirley, b. Dec. 2, 1694, d. Mar. 24, 1771, a British colonial official, advocated seizing French Canada while he was governor of Massachusetts (1741–57). A London lawyer, he emigrated to Boston in 1731 and held several posts before being appointed Massachusetts governor. During King George's War (see FRENCH AND INDIAN WARS) he initiated and planned a successful campaign (1745) against LOUISBOURG. In the French and Indian War, Shirley also headed an expedition (1755) against Fort Niagara, but its failure led to his dismissal as governor.

Shitao (Shih-t'ao) [shi-tow] The Chinese painter Shitao, also known as Daoji, b. Feb. 7, 1641, d. *c.*1710, was a leading member of the individualist school of the early Qing period. A descendant of the Ming imperial family, he became (1662) a Buddhist monk and then embarked on a painting career.

As an individualist rather than an orthodox painter, Shitao was more interested in studying nature than in studying existing painting styles. Of all the Qing individualists, he displayed the most variety and originality in style, using color more richly than any of his predecessors and inventing unique compositional arrangements. Shitao was also a well-known theorist who advocated a one-stroke technique of brushwork.

Shiva [shi'-va] One of the two principal Hindu gods (the other being VISHNU), Shiva is frequently viewed as the destroyer of the world prior to each period of dissolution. He is depicted in both terrible and graceful forms, the latter including the dancing Shiva, or Nataraja. He consorts with a mother goddess, Ambika, known by various other names such as Parvati, Uma, Durga, or Kali (see also SHAKTI), and his presence is iconographically suggested by the image of his vehicle, a bull (Nandi), or by the pillar-shaped lingam, a phallic image.

Hindus who view Shiva as the supreme deity are known as Shaivites. Among the localized sects are Kashmir Shaivism, Virashaivism, and Shaiva Siddhanta.

The South Indian bronze sculpture depicts the god Shiva, one of the principal gods in the Hindu pantheon. Shiva appears here in his protective aspect as the destroyer of evil, standing on a conquered demon. Revered as the embodiment of creative energy, Shiva represents the eternal cycles of dissolution and regeneration.

Shkodër [shkoh'-dur] Shkodër (Italian: Scutari), a town on Lake Scutari in northwestern Albania, is located 90 km (55 mi) northwest of Tiranë and 11 km (7 mi) east of the border of Yugoslavia. The population is 79,900 (1989 est.). A regional market for wool, cotton, hides, and tobacco, Shkodër processes fish and manufactures tobacco and leather products, textiles, footwear, and firearms. Shëngjin, an Adriatic port 25 km (15 mi) to the south, is linked with Shkodër by a highway. A cathedral and a 15th-century fortress are the most notable landmarks.

The capital of Illyria before the Romans conquered it in 168 BC, Shkodër passed to Serbia in the 7th century AD and became the seat of the princes of Montenegro until they sold it to Venice in 1396. Although formal control passed (1479) to the Ottoman Turks, local families continued to rule. Montenegran troops occupied the city during the Balkan Wars (1912–13), but the city was granted to Albania.

shock Shock, in medicine, is a critical condition that is brought on by a sudden drop in blood flow through the body, for any of the reasons categorized below. This reduction in blood supply results in a serious curtailment in the delivery of oxygen and nutrients to body tissues; removal of wastes from body cells is likewise impaired. A person in shock exhibits prostration, pallor, cold and moist skin, reduced mental alertness, lowered blood pressure, and decreased urine flow. If these symptoms are not treated, they can lead to death. The term *shock* has also been used for such psychological events as *shell shock*, now known as POST-TRAUMATIC STRESS DISORDER.

Hypovolemic Shock. A decrease in blood volume (hypovolemia) is the single most common cause of shock. It results from loss of blood through hemorrhaging, by loss of blood plasma through severe burn lesions, and by dehydration. In this type of shock, symptoms are a fast, uneven pulse rate; lowered blood pressure; cold sweat; dilation of the pupils; and deep, rapid breathing. Kidneys may fail because of decreased renal blood circulation, which lowers urine formation. The primary treatment for hypovolemic shock is prompt administration of intravenous fluid. If shock persists, the physician may prescribe adrenalinlike stimulants.

Cardiogenic Shock. The second most common cause of shock is heart failure, in which heart muscle fails to pump blood effectively. A heart attack, also known as acute myocardial infarction, may cause an abnormal rhythm of heartbeats because of slow, rapid, or irregular contractions of heart muscle (see HEART DISEASES). As a result, the heart's ability to pump blood may be impaired, lowering the volume of blood circulating in peripheral tissues at any given time. Arterial and venous blood vessels constrict, and adrenalinlike hormones are secreted into the bloodstream, increasing the heart rate. Cardiogenic shock may also result from the ingestion of drugs that reduce heart function, or from hypoxemia—low amounts of oxygen in the blood—due to various lung diseases. Symptoms are similar to those of hypovolemic shock, and treatment involves primarily improving the heart's function.

Vasodilation and Vasoconstriction. Faulty behavior of blood vessels underlies the third category of shock. In vasodilator disorders blood may flow directly from the arteries to the veins, depriving capillaries of oxygen. The blood vessels also may dilate, which reduces blood pressure even though the blood volume is normal. Constriction of blood vessels may cause shock because large volumes of blood are retained and pooled, especially in the veins. This defect occurs mainly because of overdoses of sedative and narcotic drugs, most commonly barbiturates. Injuries to the central nervous system can also cause vasoconstriction. Such a defect is sometimes known as septic shock when it occurs in patients having pneumonia, peritonitis, or bacterial infections of the skin, the urinary tract (kidneys, bladder), the gallbladder, or the uterus. Symptoms of septic shock include chills, then fever, increased blood flow from the heart, decreased peripheral circulation, and mental confusion. Shock due to vasodilation also results from head injuries, liver failure, poison intake, and psychological trauma that leads to fainting. Anaphylactic shock is caused by a sudden, severe allergic reaction (see ALLERGY).

Treatment for septic shock involves prompt administration of antibiotic drugs and removal of the infected site by drainage of pus or by surgery. Large doses of cortisonelike hormones are regarded as beneficial.

Blockage of Blood Flow. Severe compression or obstruction of the main stream of blood flow precludes effective blood circulation and therefore causes shock. Often this type of shock results from an embolus, a blood clot that usually forms in the legs or pelvic region, breaks away, and circulates in the bloodstream until it lodges in a large arterial or venous vessel. A frequent cause of this type of shock is pulmonary embolism. This condition is due to blockage of the pulmonary artery by an embolus that blocks the flow of blood from the heart to the lungs and, subsequently, to peripheral tissues. A characteristic symptom of shock due to a pulmonary embolism is fast, deep breathing.

Treatment of such blockage includes the administration of anticoagulant drugs or drugs that dissolve the embolus. Less commonly, the clot may be removed surgically.

First Aid. In cases of shock, the person should be kept warm and prone. The air passages should be kept open to assure adequate breathing. If there is severe bleeding, it should be stopped as rapidly as possible. The blood pressure and pulse should be monitored. In most instances, provisions must be made for the administration of fluids. Persons trained in FIRST AID and CARDIOPULMONARY RESUSCITATION are best able to provide these preliminary measures.

Lactic Acid Test. Shock causes less oxygen to be delivered to tissues; because of the oxygen deficit, lactic acid accumulates. Testing for the amount of lactic acid in the blood, therefore, gives an adequate indication of the severity of the shock: the higher the level, the more irreversible the damage.

See also: CIRCULATORY SYSTEM; RESPIRATORY SYSTEM.

shock therapy Shock therapy is the use of drugs or electricity to treat severe mental disorders by inducing coma or convulsions. Insulin therapy uses injections of increasing levels of insulin, deoxygenating the blood and producing a deep coma with diffuse motor, sensory, and autonomic effects. The therapeutic effect seems to be greatest with schizophrenic conditions of less than 2 years' duration and of good prognosis. Metrazol has also been used to produce convulsions. Complications include difficulties in controlling the reaction and intense fear experienced by the patient prior to losing consciousness.

Electroconvulsive therapy (ECT) involves a very brief passage of about 150 volts of DC electrical current between two electrodes placed on the patient's temples. This current inhibits glucose and oxygenation, causing convulsions and immediate loss of consciousness. ECT is administered about three times weekly for 2 to 6 weeks. Side effects include temporary memory loss, intellectual impairment, and a slight risk of fractures and respiratory failures. ECT seems to be most effective with severe depressions; its effect on schizophrenia is uncertain. ECT has been used with children for the reduction of hyperactivity and autism, but this application has fallen into disrepute.

In contemporary practice the shock therapies have generally been supplanted by psychoactive drugs. ECT is still in use, however, with severe, chronic, and intractable depression, because some patients seem to improve at least temporarily as a result. These results may be linked in some way with the observed increase in levels of beta endorphin in the blood of patients after ECT.

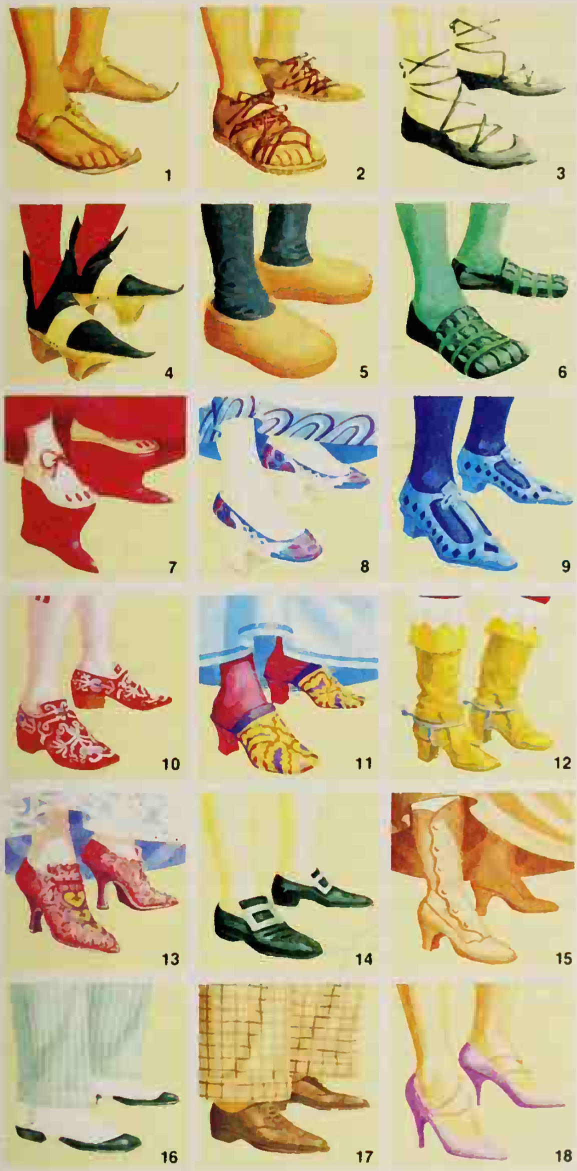
See also: PSYCHOPATHOLOGY.

shock wave A shock wave is a high-intensity sound wave in which very large and rapid changes of pressure, density, and temperature occur as the wave passes. The sudden pressure change exerts forces that can cause damage to objects in its path. Shock waves are caused by explosions in the atmosphere or underwater, and by spark discharges such as lightning. Another common source of shock waves is the supersonic flight of an airplane. In this case the pressure disturbances cannot propagate away as fast as the onrushing source; the shock front is perceived as a sonic boom.

Shockley, William [shahk'-lee] The American physicist William Bradford Shockley, b. London, Feb. 13, 1910, d. Aug. 13, 1989, shared the 1956 Nobel Prize for physics with John Bardeen and Walter Brattain for the invention of the TRANSISTOR. Shockley had been working at Bell Telephone Laboratories since 1937 when the team developed (1948) a way to alter semiconductor crystals so that they could both detect and amplify radio waves. In 1963, Shockley became a professor of engineering science at Stanford University. Beginning in the late 1960s, Shockley caused great controversy by his active support of the view—explored in the work of people such as Arthur Jensen—that intelligence capacity is a genetic trait of races.

shoe The first "shoes" may have been pieces of rush, bark, or hide tied around the foot to protect the sole. The Egyptians made sandals of woven palm and papyrus leaves. The Greeks and Romans had similar sandal styles that were made of felt, wood, or leather, with a flat sole and lacings. In making these shoes they differentiated between the right and left foot and cut the flat sole to follow the outline of the foot. The Romans rarely went barefoot, and styling was important because certain shoes indicated the social position of the wearer.

The rise to prominence of the guilds in medieval Eu-



In ancient Egypt, sandals (1) *were made of organic material or leather, as were Roman sandals* (2), *adopted from the Greeks. During the early Middle Ages, leather-soled shoes* (3) *were laced to leggings with thongs. By the late 1300s a continuing trend to elongated toes reached new extremes in Crakows* (4), *which were worn with wooden platforms called pattens. Sabots* (5), *heavy clogs, were worn by peasants throughout Europe. During the 15th century the fashion of slashing extended even to shoes* (6), *which were broad and square. Chopines* (7), *which elevated the wearer to extraordinary heights and protected both feet and hem from dirt, resembled the footwear* (8) *worn contemporaneously by Manchu women in China. By the last quarter of the 16th century shoes had acquired small heels* (9). *At that time leather soles and embroidered uppers* (10) *had become common in England; in France wooden heels were attached to slippers* (11). *Cavalier fashion popularized lace-cuffed, spurred boots* (12). *At the court of Louis XIV of France, curved high heels* (13) *came into vogue. During the 19th century, lower heeled shoes* (14) *sported a metal buckle over the tongue. During the late 1800s women's skirts rose to the ankle; ankle boots* (15) *with side buttons were worn outdoors. Side buttons also appeared on men's spats* (16). *During the 20th century oxfords* (17) *became the prevailing style for men. "Spike" heels* (18) *were fashionable for women during the 1950s.*

rope supported the craft of the cobbler, or cordwainer—the latter term being derived from Córdoba, the Spanish city famed for its leather. In the 13th century fashionable men wore shoes with long, pointed toes. The toe points became so exaggerated that they were sometimes fastened to the knee by slender chains. Eventually the bizarre lengths were regulated by law—royalty could wear toes of one length, commoners another—but it was not until the end of the 15th century that the craze died out. By then some people wore soled hose with wooden clogs designed to protect the feet from muddy streets, or thick-heeled soles of cork and wood, called pattens. An exotic variant, originally from Turkey, was the chopine, a wooden clog that could reach stilt height.

With Queen Elizabeth I came a narrower, heeled shoe for women. Novel decorations—shoe roses—of ribbon and lace were attached. Men wore soft, thigh-high boots with heels. The jack boot, a stiff boot favored by American planters in the colonies, appeared about 1665. The end of the century brought renewed popularity to low shoes, with red heels, square toes, and huge bows or buckles.

The 18th century brought a French fashion influence, and women wore beautifully decorated leather or silk shoes, on high heels that were set under the arch of the foot. After the French Revolution an enthusiasm for classic fashion brought back flat heels and sandals, and English-style country clothes worn with sturdy boots. In Victorian England dainty feet were much admired. Slippers with square toes were fastened by ribbons that crossed and tied at the ankle. When Victorian ladies ventured outside, they wore cloth boots with elastic side panels.

The Industrial Revolution changed the making of shoes with the development of machines that could attach inner to outer soles with pegs, and machines that could sew uppers to lowers. Modern mass-production methods rapidly evolved and are essentially those still used today. They include cutting the parts of the upper; stitching these parts together; selecting and preparing the sole; lasting, or shaping, the upper on a wooden or metal form; bottoming (attaching the sole to the upper); heeling (attaching the heel); and finishing (cleaning and polishing). Modern innovations include the development of plastic substitutes for LEATHER, as well as the trend toward wearing sneakers (especially running shoes) as standard footwear for all ages.

See also: COSTUME.

Shoemaker, Willie The American jockey William Lee Shoemaker, b. Fabens, Tex., Aug. 19, 1931, rode in and won more Thoroughbred races than anyone in history.

Willie Shoemaker, in 1970, rode his 6,033d winner, breaking Johnny Longden's record. During his long career Shoemaker won 11 Triple Crown races: 4 Kentucky Derbies (1955, 1959, 1965, 1986), 2 Preaknesses (1963, 1967), and 5 Belmont Stakes (1957, 1959, 1962, 1967, 1975).

Shoemaker rode his first winner in 1949 at the age of 17, and at age 22 he set a record that stood until 1977—485 victories in one season. Twice, in 1968 and in 1969, he suffered serious injuries that left his career in doubt, but each time he recovered and staged a remarkable comeback. Shoemaker did not retire as a jockey until 1990. During his career he rode in 40,350 races, with 8,833 first-place, 6,136 second-place, and 4,987 third-place finishes—all records at the time of his retirement. His mounts won purses totaling $123,375,524.

shofar [shoh'-far] The shofar is a ritual Jewish wind instrument dating from biblical times, still used in celebration of the Jewish New Year. A ram's horn with a mouthpiece carved into it, the instrument is capable of producing only two pitches. A few composers have imitated its sound in oratorios, as in Sir Edward Elgar's *The Apostles.*

shogun [shoh'-guhn] Shogun, or general, was a title granted to Japanese military leaders. Yoritomo became shogun in 1192, and the Kamakura shogunate, which he had founded in 1185, supplemented imperial authority until 1333, marking the beginning of the shogunate as a mode of martial rule. Military power expanded until the Ashikaga (or Muromachi) shogunate (1338–1573) came to dominate the imperial government. When the Ashikaga lost control of their vassals after 1467, authority was diffused to local military leaders, the daimyo. In the latter part of the 16th century, Nobunaga and Hideyoshi recentralized shogunal control, but Nobunaga died before realizing his goal of Japanese unification, and Hideyoshi, who did succeed in ruling a united Japan, failed to assure his family's succession.

Authority passed to Ieyasu, who consolidated his position and assured Tokugawa family control. The Tokugawa amassed enormous power and presided over a military-bureaucratic structure that dominated national politics from about 1600 to 1868, while individual daimyo controlled their own domains and paid the Tokugawa fealty. The shogun certified daimyo land titles and family succession, enacted laws and controlled foreign policy, instituted a class system, and regulated religious institutions and the imperial court. Internal and external unrest resulted in the collapse of the Tokugawa regime and the Meiji Restoration in 1868.

Sholokhov, Mikhail Aleksandrovich [shaw'-luh-kuhf] Best known outside the Soviet Union for his monumental novel *And Quiet Flows the Don*, Mikhail Sholokhov, b. May 24 (N.S.), 1905, d. Feb. 21, 1984, was a controversial figure in the West because of his strong support of Soviet Communism. Born in a Cossack village in the Don River region, Sholokhov fought against antirevolutionary groups as a boy, and in 1922 he went to Moscow to study. He soon began to publish short stories. A 4-volume narrative dealing with the life of the Cossacks during the Bolshevik revolution and Russia's Civil War (1918–23), begun by Sholokhov in 1926, finally evolved into *And Quiet Flows the Don* (1928–40; Eng. trans. in 2 vols., 1934 and 1940, the second volume being titled *The Don Flows Home to the Sea*). Sholokhov was awarded the Nobel Prize for literature in 1965.

Two other ambitious novels suggest the scope of Sholokhov's total literary undertaking: *The Virgin Soil Upturned* (2 vols., 1932–33 and 1960; Eng. trans., 1935 and 1960) covers the collectivization of agriculture among the Don Cossack farmers in the 1930s, and *Oni srazhalis' za rodinu* (They Fought for the Fatherland, 1944), which remained unfinished, depicts the heroism of Stalingrad's defenders during World War II. Although compelling portraits of traumatic events in modern Russian history, these volumes, exemplary of socialist realism, are less successful as works of art.

Shona [shoh'-nuh] The Shona are a Bantu-speaking people of southern Africa living in Zimbabwe and in parts of Mozambique. In the 1980s they numbered approximately 6 million, including, among other groups, the Karanga, Korekore, Manyika, and Zezuru. Their ancestors are thought to have been associated with the ancient Zimbabwe culture centered in southern Zimbabwe (see Zimbabwe ruins). Although the political coherence of the Shona nation was shattered by intruders, particularly the Ndebele and the British in the 19th century, the Shona maintained much of their cultural identity, notably their language and religion. There are indications that traditional symbolic thought and religious practices have helped the Shona to withstand foreign culture and influence.

shooting Target shooting is a competitive sport in which contestants fire guns at fixed or moving targets. Shooting also has a practical purpose—military units and police forces use target practice to develop marksmanship, and hunters use moving targets that simulate the movement of game.

Three types of firearms are commonly used in target shooting—rifle, pistol, and shotgun. Rifle shooting is conducted in small-bore (.22 caliber) competition, with targets set 50 or 100 yd (45.7 or 91.4 m) away in U.S. matches and 50 m (55 yd) in international events. Bigbore (over .25 caliber) competitions range in distance from 200 to 1,000 yd (182.9 to 914.4 m) in the United States and distances are standard at 300 m (330 yd) in international competition. International shooting rules require a set number of shots from a standing, sitting, or prone position.

Pistol shooting includes matches for .22 caliber pistols, center-fire pistols (usually .38 caliber), and .45 caliber service pistols and .45 caliber semiautomatic pistols. Targets are at distances of 50 ft (15.2 m), 20 yd (18.3 m), 25 yd (22.9 m), 50 yd (45.7 m), and 50 m (55 yd), for various U.S. and international competitions. The National Rifle and Pistol Championships, conducted by the National Rifle Association (NRA), are held every summer at Camp Perry, Ohio.

The shotgun events are trapshooting and skeet. A total of 25 shots is taken in each category at saucer-shaped ceramic targets known as clay pigeons. In trapshooting, targets are released in a direction heading away from the shooters from a trap house (a spring-loaded device that launches the clay pigeon) 16 yd (14.6 m) in front of the shooters, who are arrayed in a semicircle at five adjacent stations. Five shots are taken from each station. For skeet, high- and low-flying targets are launched from trap houses at either end of a semicircle 120.75 ft (36.8 m) across that has eight designated shooting stations. One target from each house is shot at from every station by each contestant. These are followed by simultaneous launches of targets from both houses requiring two rapid-fire shots, from four of the stations. The 25th shot is either a repeat of the first miss or an optional shot. The most prestigious clay-pigeon events are the Grand American Trapshooting Tournament, conducted every August at Vandalia, Ohio, by the Amateur Trapshooting Association (ATA), and the World Skeet Shooting Championships, conducted each summer by the National Skeet Shooting Association (NSSA), headquartered in San Antonio, Tex.

Since 1907 international competition has been governed by the International Shooting Union (ISU), which every 4 years conducts a world championship and now comprises the shooting federations of 108 countries. Shooting has also been an Olympic Games event since 1896.

A sharpshooter shows proper technique for free pistol target shooting. This event requires that the pistol be held in one hand only. Competitors are permitted 60 shots over a period of 2½ hours.

shooting star see METEOR AND METEORITE

Shore, Dinah Singer Dinah Shore, b. Frances Rose Shore in Winchester, Tenn., Mar. 1, 1921, was one of the last of the pre-rock-generation pop-music stars. She began her career on a New York radio station in 1938, and after singing on several radio shows she achieved nationwide fame with her 1941 record, "Yes, My Darling Daughter." As a radio, recording, and film star, Shore remained a major name through the 1950s. Her television show, "Dinah!," as well as a women's professional golf tournament that bears her name, have kept her in the public eye.

Shore Patrol The Shore Patrol is the U.S. Navy's police force. Comprising officers and petty officers, it patrols naval bases and areas visited by naval personnel on shore leave. The Shore Patrol is analogous to the Military Police (see MILITARY POLICE) of the Army and Marine Corps and the Security Police of the Air Force. Police functions for the U.S. Coast Guard are also carried out by a force termed the Shore Patrol.

shorebirds Shorebirds are grouped into 12 families belonging to the suborder Charadrii, order Charadriiformes. Their plumages are generally marked by plain or cryptic patterns and colors that blend with the background. They range in length from 13 to 61 cm (5 to 24 in), legs vary among genera from short to long, and bill shapes are specialized according to different feeding habits. Shorebirds are typically strong fliers, and many species make long migratory flights. They eat mainly animal foods, ordinarily foraging on the ground and sometimes in shallow water. They usually nest on the ground.

The seven species of jacanas, family Jacanidae, occur worldwide in tropical and subtropical areas, where they inhabit lake and stream margins. Their feet are specialized for walking over floating vegetation such as lily pads.

The painted snipes, family Rostratulidae, include two species of widespread tropical and subtropical marsh birds with moderately long legs and bill, and a short neck.

Oystercatchers, family Haematopodidae, are six species of birds ranging along temperate and tropical coastlines; they may be all black, or black and white. Their red bill is long and laterally compressed. Sandpipers, family Scolopacidae, include 82 species that have worldwide distribution. They have various bill shapes, ranging from moderate to very long as well as straight, decurved, or recurved.

The 63 species of plovers, family Charadriidae, occur worldwide. The bill ranges from straight and short to moderately long. The best-known plover in North America is the killdeer, which distracts enemies from its nest by feigning a broken wing; when the predator is sufficiently lured away from the nest, the killdeer drops its pose and flies away.

The family Recurvirostridae includes seven species of stilts and avocets, which usually wade and swim in shallow water. These birds have long bills and legs. The phalaropes, family Phalaropodidae, are northern birds that often swim in circles to stir up small animal prey.

The heavy-billed crab plover, *Dromas ardeola*, of the Old World, is the only species in the family Dromadidae. The thick-knee family, Burhinidae, contains 9 species of nearly worldwide distribution outside of North America. The family Glareolidae (pratincoles and coursers) includes 17 species of Old World shorebirds. The 4 species of seedsnipes, family Thinocoridae, are short-legged, short-billed, and mainly vegetarian birds of South America. The 2 species of sheathbills, family Chionididae, are limited to areas near Antarctica.

short story First formally defined (1842) by Edgar Allan Poe as an artistic composition controlled to produce a single unified effect, the short story is, in the broadest sense, a prose narrative that can be told or read on a single occasion. Originating with primitive accounts of supernatural encounters, short narratives have existed in the form of parables, fairy tales, folktales, legends, and fables throughout history.

Nathaniel Hawthorne, the first American master of the short story, used supernatural encounters typical of the folktale in such stories as "Young Goodman Brown" (1835) to symbolize complex moral problems. Poe borrowed from the older supernatural tale to illustrate psychological complexities, as in "The Fall of the House of Usher" (1839). By 1853, when Herman Melville published "Bartleby the Scrivener," the focus of the short story had shifted from the supernatural event to the psychological and moral implications of a natural, although still strange, realistic encounter.

Meanwhile, short fiction combining folktale material with formal artistic technique was also being written in France by Prosper Mérimée ("Mateo Falcone," 1829) and Honoré de Balzac ("A Passion in the Desert," 1830) and in Russia by Nikolai Gogol ("The Overcoat," 1842) and Ivan Turgenev (*A Sportsman's Sketches*, 1852).

Later in the 19th century, the emphasis on realism favored the novel over the basically symbolic short story. In the 1880s and '90s, however, short fiction gained a new impetus from the complex irony and artistic objectivity of Guy de Maupassant in France, Anton Chekhov in Russia, Henry James in the United States, and Joseph Conrad in England. The short story became less a parable illustrating moral and psychological problems than an embodiment of these problems in a narrative of extreme complexity and self-consciousness.

Combining realism of incident with symbolic overtones and artful form, James Joyce (*Dubliners*, 1914) and Sherwood Anderson (*Winesburg, Ohio*, 1919) greatly extended the possibilities of the genre. In the 1920s, '30s, and '40s, the most masterly practitioners of the short story were such American writers as Ernest Hemingway, F. Scott Fitzgerald, William Faulkner, Katherine Anne Porter, and Eudora Welty.

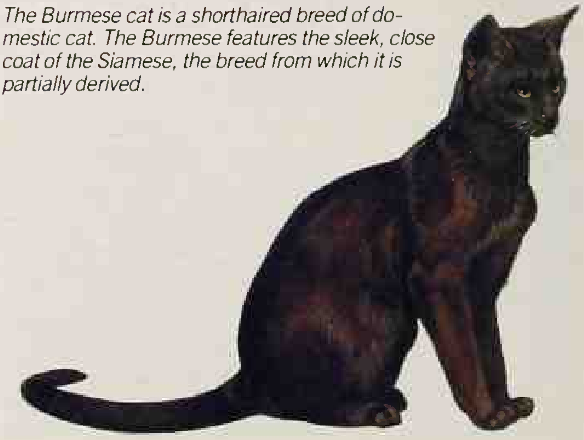
Although their now traditional approach to the short story is still evident in the works of such writers as Peter Taylor, John Updike, Joyce Carol Oates, and Bernard Malamud, another group of writers broke free from the realistic form to return to the fabulistic narrative developed by Poe and Hawthorne. The stories of Donald Barthelme, William H. Gass, John Barth, and Robert Coover employ this mode to explore the forms of fiction itself.

Short Takeoff and Landing Aircraft see STOL

Shorter, Frank Frank Shorter, b. Munich, Germany, Oct. 31, 1947, was an American world-class distance runner. In 1969, as a member of the Yale University track team, he was the National Collegiate Athletic Association (NCAA) 6-mi (9.6-km) champion. Persuaded by a teammate to try the marathon, Shorter entered his first 26 mi-385 yd (42.2-km) race in the Pan American Games in São Paulo, Brazil, and became the first American ever to win that particular race. In the 1972 Olympic Games he won the gold medal in the marathon, and he was the silver medalist in the 1976 Olympics.

shorthaired cats Domestic cats belong to either the longhair or the shorthair categories. Although longhaired cats are prized for their showy appearance, shorthaired cats do not require as much grooming, and shedding of hair presents less of a problem.

Particular breeds of shorthairs include the Siamese, the Abyssinian, and the Burmese cats. The Siamese has very short hair and blue, slightly crossed eyes. Its evenly colored coat is marked by points—darker patches of color



The Burmese cat is a shorthaired breed of domestic cat. The Burmese features the sleek, close coat of the Siamese, the breed from which it is partially derived.

on its face, ears, paws, and tail. The Abyssinian is a large, slender cat with a ticked reddish coat—that is, each hair has two or three distinct bands of color. The Burmese, bred partly from Siamese, is of medium size and rich, sable brown color.

The Havana Brown, the Japanese Bobtail, the Korat, the Russian Blue, and the Manx are all shorthairs that are relatively rare but nevertheless popular. Although the Maine coon cat has medium-long hair and is believed to have Persian ancestry, it is sometimes considered a shorthair.

The best-known American domestic shorthairs are the tabby cats, which have striking patterns of stripes or whorls on their brown, red, or silver coats; the tortoiseshell, with patches of red, black, and brown; and the calico, which has patches of white mixed in with the red, black, and brown patches. Other American domestic shorthairs include cats having pure black, white, or blue coats of fur.

shorthand Shorthand, or stenography, is any system of writing that makes uses of symbols and characters in order to quickly record information—usually spoken—in abbreviated form. Shorthand was a widely practiced craft in ancient Rome, and a method devised by Marcus Tullius Tiro, Cicero's secretary, known as the Tironian Notes, was exported to Egypt in AD 155. With the advent of the medieval era, however, the use of shorthand died out. Timothy Bright's *Characterie: An Arte of Shorte, Swifte, and Secrete Writing by Character* (1588) led to the revival of shorthand.

In the following years numerous publications elaborated other shorthand systems. In 1837, Sir Isaac Pitman published the first edition of his system, which is still the most widely used shorthand outside the United States. Pitman shorthand is based on phonetic classifications and uses straight and curved lines of varying lengths and shadings to construct the symbol for a word.

The Gregg system of shorthand, invented by John Robert Gregg in 1888 as an alternative to the Pitman method, predominates in the United States and Canada because of its simplicity. The Gregg system replaced the geometric Pitman symbols with cursive strokes of uniform thickness.

Other shorthand methods include those, such as speed writing, which simply abbreviate longhand writing. Machines are also used to transcribe information in shorthand. The Stenograph, or Stenotype, machine, which is similar in appearance to a typewriter, enables the user to record shorthand silently and quickly.

shorthorn cattle see CATTLE AND CATTLE RAISING

Shoshoni [shoh-shoh'-nee] The Shoshoni (Shoshone) are a North American Indian people who traditionally were distributed from Death Valley, Calif., northeastward through Nevada, southern Idaho, southwestern Montana, and much of western Wyoming and Utah. Western Shoshoni were food gatherers in California, Nevada, and Utah. Northern Shoshoni included root and salmon eaters of the Plateau and bison hunters in Wyoming. SACAGAWEA, the woman who guided the Lewis and Clark Expedition for a time, met her Shoshoni relatives in Montana. Among names given by white people to various Shoshonean groups were Snake Indians, Digger Indians (also applied to the PAIUTE), and Grass Lodges. In 1845 the Shoshoni numbered an estimated 4,500.

The semiarid Great Basin was the original heartland of Shoshonean-speakers, whose language, classified within the Shoshoni-Comanche division, is related to Uto-Aztecan (see INDIAN LANGUAGES, AMERICAN). In summer, families would scatter in search of sparse food, living a simple foraging existence that can be traced back to about 8000 BC; in fall and winter, families would regroup for festivals and rabbit hunts. Acquisition of horses about AD 1700 changed the Shoshoni in Wyoming and Idaho. Local groups merged under "tribal" leaders. Horse-riding Shoshoni, especially the Wind-River and COMANCHE groups, adopted many Plains traits, including SCALPING, feather headdresses, and the TEPEE. In the late 1980s the Shoshoni living on reservations in Wyoming, Utah, Idaho, and Nevada totaled more than 7,500.

Shostakovich, Dmitry [shahs-tuh-koh'-vich] Dmitry Dmitrievich Shostakovich, b. Saint Petersburg, Sept. 25 (N.S.), 1906, d. Aug. 9, 1975, was one of the foremost 20th-century Soviet composers. Accepted into the Petrograd Conservatory in 1919, he studied piano with Leonid Nikolaev and composition with Maximilian Steinberg. The sensational premiere in 1926 of his First Symphony and its subsequent successes abroad identified him as the leading young composer in Russia after the Revolutions of 1917.

Drawn into a semiofficial role as representative of Soviet music, his career evolved in the constant glare of publicity. He responded by composing many works of a topical character, among them 4 of his 15 symphonies—the 2d, *To October* (1927), the 3d, *May First* (1929), the 11th, *The Year 1905* (1957), and the 12th, *The Year 1917* (1961).

An interest in modernist devices, love of irony (both in choice of subject and its treatment), and commitment to personal creative vision brought him repeatedly into the center of controversy. His opera *The Nose*, produced in Leningrad in 1930, was withdrawn under attack for its "bourgeois decadence." In 1936, *Pravda* declared *Lady Macbeth of Mtsensk*, another of his operas, "a mess instead of music." He was chastised along with Sergei Prokofiev in 1948 for "formalistic excesses" counter to the spirit of socialist realism. His Thirteenth Symphony (1962), which memorialized the Jews massacred by the Nazis at Babi-Yar, angered Communist officials by implicitly criticizing residual Soviet anti-Semitism.

Following Prokofiev's death in 1953 and his own admission into the Communist party in 1960, Shostakovich was widely acclaimed the foremost Soviet composer—a position still unchallenged when he died. His musical language remained rooted in tonality, despite free dissonance, intricate counterpoint, and even transient dodecaphony (12-tone style). A refined eclecticism and flair for musical satire survived even the dark subjectivism of his last works, as in the references to Rossini and Wagner in his Fifteenth Symphony (1971). The authenticity of his dictated memoirs, smuggled into Europe and published as *Testimony* (1979), was disputed by family members. His son Maxim Shostakovich, b. May 10, 1939, a pianist and conductor of the Moscow Central Radio and Television Symphony Orchestra, decided to stay in the West while visiting Europe in 1981.

shot put see TRACK AND FIELD

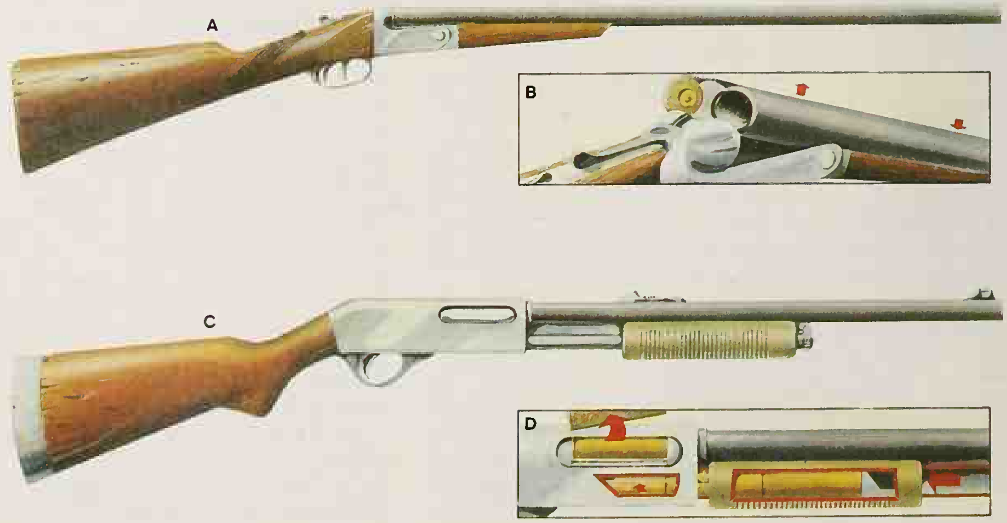
shotgun A shotgun is a smooth-bore firearm that fires a charge of small, round pellets known as shot. Shotguns are used primarily for shooting small ground game or flying birds. Handguns were first designed principally as weapons of war, but by the early 17th century firearms were well established as sporting arms. The double-barreled shotgun was developed in order to give sportsmen two consecutive shots without reloading. Early models appeared with barrels either side by side as in the modern conventional double-barreled shotgun or superimposed one above the other in what is known today as the over-and-under or under-and-over gun. Guns with three and four barrels also appeared during the 19th century, but they were cumbersome and heavy and never became popular. Semiautomatic shotguns have a magazine and are reloaded and recocked by moving some part of the gun, usually the front handguard, by hand. (This procedure has given rise to the nickname pump gun or trombone gun.) Self-loading guns work on the same principle as self-loading rifles and employ recoil or gas action to operate the mechanism. Shotgun magazines can hold up to five cartridges.

Shotoku Taishi [show'-toh-koo ty'-shee] The Japanese prince Shotoku Taishi, 573–621, introduced into Japan various cultural elements borrowed from the Chinese that effected important transformations in Japanese civilization. He was a son of Emperor Yomei, who ruled only briefly. His aunt, Empress Suiko (r. 592–628), ascended to the throne after a period of clan feuding, and in 593, Shotoku was appointed regent; until his death he exerted considerable influence in this position. A member of the powerful Buddhist Soga clan, he worked to spread his religion, building many Buddhist temples, most notably the Horyuji Temple at Nara.

Shotoku returned to the imperial family powers that had passed to the feudal nobles. He emulated the Chinese bureaucratic system of government, setting up a system of court ranks that encouraged the addition of merit to the traditional qualification of heredity as a requirement for office-holding and advancement. He sent missions to China, resuming communications that had been cut off in the 5th century. Chinese and Korean craftsworkers, the Chinese calendar, Chinese aesthetic values, and many elements of both Buddhism and Confucianism were introduced into Japan, which was at that time overwhelmingly Shintoist.

A so-called constitution of 17 articles that set down Confucian principles of government and ethics was allegedly issued by Shotoku in 605. Although the document may have been a later forgery, it was in the spirit of Shotoku's thinking.

showboats Showboats were floating theaters that brought plays and, ultimately, circuses and vaudeville to people along the great rivers of the American Midwest. The heyday of the showboats was just before and after the U.S. Civil War, and they remained popular until radio and the movies supplanted them. The first riverboat specifi-



(A) *A double-barreled shotgun is loaded* (B) *by "breaking" the barrels—moving them forward and pulling them downward. The used cartridges are ejected, and new cartridges can be inserted.* (C) *A pump-action shotgun is loaded* (D) *by inserting up to five cartridges through the port in the side of the gun into the magazine. When the front hand guard is pumped, a spent cartridge is ejected, a new cartridge is moved into position, and the firing mechanism is cocked.*

cally designed to house plays was built in 1831, when William Chapman became the first showboat manager; by 1910, 26 showboats served the Midwest. The largest showboat, Spaulding and Rodgers' Floating Circus Palace (1851–62), seated 3,400 patrons and carried 100 people and 40 animals.

shrapnel Shrapnel, the metal fragments scattered by an exploding military shell or grenade, are named after the original exploding shell invented by the British general Henry Shrapnel (1761–1842). This device was an iron shell equipped to explode in midair and scatter lead balls with lethal effect. The shrapnel ball currently used by U.S. troops contains 104 small balls, each designed to explode into 600 fragments.

Shreveport [shreev'-pohrt] Shreveport, a city on the Red River in northwestern Louisiana, is the seat of Caddo Parish. The population of the city is 198,525 (1990); that of the metropolitan area is 334,341. Shreveport is a commercial, industrial, and distribution center for the surrounding parts of Arkansas, Louisiana, and Texas.

Petroleum, natural gas, cotton, and lumber constitute the area's main resources. Machinery, metal products, chemicals, telephones, and processed food are manufactured. Centenary College of Louisiana (1825) and a branch of Louisiana State University (1964) are located in the city. Of interest are the state fairgrounds and the remains of Confederate Fort Humbug (defended by fake cannons during the Civil War).

Shreveport, established in the 1830s, became an important timber-milling and cotton-distribution center after Henry Miller Shreve cleared (1835) the Red River of a 260-km (160-mi) log jam, called the Great Raft, to open it for navigation. Railroad commerce superseded river traffic by the late 19th century. Discovery of petroleum in 1905 spurred development.

shrew Shrews are approximately 200 to possibly 290 species of small mammals constituting the family Soricidae in the order Insectivora. They are mouselike in general appearance but have longer, pointed snouts, small ears, and tiny eyes. Their fur is short and dense and usually brown or gray in color. Shrews are found in North and Central America and the extreme northwestern tip of South America, in Eurasia, and in Africa. Most are terrestrial and commonly live near streams or other moist sites. Some species, called water shrews, are aquatic.

Shrews are the smallest of all living mammals, ranging in size from Savi's pygmy shrew, *Suncus etruscus*, of Eurasia, which is 60 to 80 mm (2.4 to 3.1 in) long, including its tail, and 1.5 to 2 g (0.05 to 0.07 oz) in weight, to the rat-sized African forest shrew, *Praesorex goliath*, which reaches 290 mm (11.4 in) in length, including its 110-mm (4.3-in) tail, and 180 g (6.3 oz) in weight.

The North American pygmy shrew is a quick, nervous mammal related to the mole. Its pulse rate is 1,000 beats per minute.

Because of their high metabolic rate, shrews must normally eat about two-thirds of their body weight in food each day; under certain conditions, such as when the female is nursing young, this intake may be much higher. Shrews feed mainly on insects but commonly take a wide variety of animal foods.

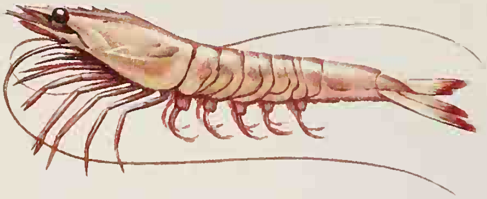
The elephant shrews are mouse- to rat-sized mammals of the family Macroscelididae in the order Insectivora. They have long, somewhat flexible snouts, large eyes, and long hind legs. The 16 to 28 species are native to Africa, where they are found from open plains to forest.

The otter shrews are 3 species of aquatic African insectivores classified either as a subfamily of the tenrecs, family Tenrecidae, or as a family of their own, Potamogalidae. They are the largest of the insectivores, the giant otter shrew, *Potamogale*, reaching about 60 cm (2 ft) in length, almost half of which is the powerful tail.

shrike Shrike is the common name for predatory birds belonging to the family Laniidae. Shrikes are perching birds, measuring about 16 to 37 cm (6 to 14 in) in length. They have large heads, and they often impale their prey on thorns and tear it with their strong, sharp bills. Two species inhabit North America: the widely distributed northern shrike, *Lanius excubiter*, and the loggerhead shrike, *L. ludovicianus*. Adults of both species are gray above and white below, with bold, black eye stripes. Their wings and tails are black and white.

shrimp Shrimp is the common name applied to about 2,000 species of crustaceans constituting the suborder Natantia in the order Decapoda, which also contains the suborder of lobsters and crabs. They range in size from about 6 mm to 20 cm (¼ to 8 in); the larger forms are commonly referred to as prawns. Shrimps are predominately marine, but several families have invaded fresh or brackish waters, and one species that lives in mangrove swamps in South America is semiterrestrial. Most are bottom dwellers; others swim in the open sea. Shrimps usually feed on small animal or plant organisms, but some are scavengers. Several genera form the basis of a major fishery, and some shrimps are commercially raised.

Shrimps generally have a laterally, or side-to-side, compressed body, which is divided into three parts: head,



The common pink shrimp, a crustacean, lives on tropical ocean floors in shallow waters. Like other shrimp species, it has a plated outer skeleton, long antennae, and ten pairs of legs.

thorax, and abdomen. The head bears eyes on stalks, and long antennae. Arising from the thorax are eight pairs of appendages: the first three pairs near the head are modified into mouthparts called maxillipeds; the remaining five pairs are the walking legs, or pereipods. The abdomen has five pairs of swimming legs, or pleopods, and one pair of uropods, which form part of the fanlike tail. The head and thorax are fused and covered by an overhanging shell called the carapace, which encloses the gills. Shrimps swim by paddling with the pleopods of the abdomen and also by rapid and repeated bendings of the abdomen and tail.

The suborder Natantia is divided into three sections: Penaeidea, Caridea, and Stenopodidea. The Penaeidea are characterized by the presence of small pincers (chelae) at the ends of the first three pairs of walking legs; the Caridea by pincers on only the first two pairs; and the Stenopodidea by pincers on three pairs, but with at least one leg of the third pair larger than those of the other two pairs.

Shriver, Sargent [shry'-vur] The American lawyer and politician Robert Sargent Shriver, Jr., b. Westminster, Md., Nov. 9, 1915, was an unsuccessful Democratic candidate for vice-president in 1972. Educated at Yale, he married Eunice Kennedy (see KENNEDY family). Shriver worked as business manager for his brother-in-law John F. Kennedy's 1960 presidential campaign. He was the first director of the Peace Corps (1961–66), director of the Office of Economic Opportunity (1964–68), and ambassador to France (1968–70). In 1972, Shriver replaced Thomas EAGLETON as George McGOVERN's vice-presidential running mate.

Shropshire see SALOP

Shroud of Turin The Shroud of Turin, an ancient piece of linen bearing the image of the front and back of a crucified man about 2 m (6 ft tall), has been believed by many people to be the actual burial cloth of Jesus Christ. The shroud, 4.34 m (14 ft 3 in) long and 1.09 m (3 ft 7 in) wide, can be traced through documentation back to 1354, but its history before that date is obscure. Since 1578 it has been preserved and venerated in the cathedral of Turin, Italy. Details of the biblical account of Christ's burial—specifically the washing and anointing of the body—conflict with the natural possibility of an imprint such as that on the Shroud of Turin, and Vatican-sponsored scientific tests conducted in 1988 indicated that the shroud itself dates no earlier than 1260.

shrub A shrub is a woody, perennial plant that usually has more than one main branch or stem originating above or below ground, unlike a tree, which has a single trunk. The height at which a woody plant becomes a tree varies arbitrarily from 4 to 8 m (13 to 26 ft). Some cultivated shrubs such as hollies may have the potential to become trees if unpruned.

Shrubs range in form and height from such prostrate types as the manzanita and the creeping juniper to the treelike sumac and the crape myrtle. Growing conditions will modify a shrub's form and height. For instance, a species of alder growing near timberline may have several trunks and be classified as a shrub; in temperate zones the same species may have a single trunk and be designated a tree.

Herbs are popularly separated from shrubs because of their low growth, lack of winter hardiness, or lack of a woody stem, or because many of them are annuals. Such perennials as rosemary and lavender, however, qualify as shrubs in warmer regions. Woody vines, including poison ivy, Virginia creeper, and grape, are sometimes classified as shrubs by botanists.

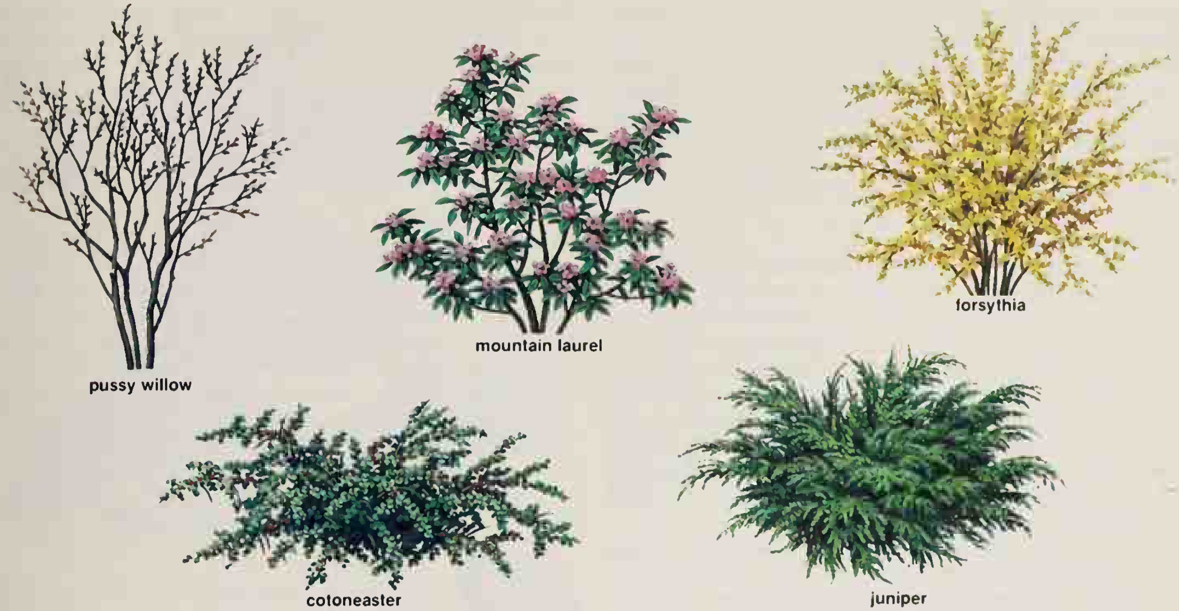
Benefits and Drawbacks of Shrubs

In arid and semiarid regions of the world, shrubs can provide food for wildlife and domestic livestock as well as provide camouflage and shelter for small animals. Shrubs act as soil stabilizers by trapping surface soil blown by wind against their branches. In forests shrubs provide food and shelter as well as assist in the establishment and growth of overhead tree vegetation. Shrubs often create the proper light and soil conditions for seed germination of other vegetation in forests. Many ornamental shrubs, such as azalea, tea rose, boxwood, forsythia, and jasmine, add beauty to landscaped lawns and parks. Among the more prominent ornamental species native to the United States are the mahonia, acacia, desert willow, elderberry, and rhododendron.

In some managed ecosystems, such as a commercial timber stand, or on rangeland that is used for grazing livestock, shrubs may be undesirable because they compete with trees or grass for light, water, and nutrients. In these instances, controlled fire, herbicides, or mechanical equipment is used to reduce shrub competition. In the commercially valuable loblolly-pine forests of the southern United States, for example, the yaupon holly—an ornamental on house grounds and a source of food for wildlife—is considered a pest.

Classification

Shrubs are generally classified into families that differ in flower and leaf arrangement. Conifers, which are cone-bearing plants, include the shrubby junipers, family Cu-



Woolly catkins appear on pussy willows, signaling spring. The mountain laurel bears elliptical leaves and white to rose flowers. Shrubs of the genus Forsythia *are noted for their bright yellow flowers in early spring. Several shrubs of the genus* Cotoneaster *have red or black fruit. The sprawling, dense leaves of many junipers make excellent ground cover.*

pressaceae, and yews, family Taxaceae. Monocotyledons, bearing one seed leaf, include yuccas, family Agavaceae, and bamboos, family Gramineae. Dicotyledons, which bear two seed leaves, are subdivided as shrubs with flowers that lack petals—for example, willows, wax myrtles, and the common fig—and shrubs with petals on their flowers—for example, the barberry, magnolia, anise, papaw, and spicebush. Shrubs are most prominent in the rose family, Rosaceae, which includes the rose, cotoneaster, blackberry, and hawthorn.

Shrubs are often described according to their size and landscape contribution; for instance, some medium-sized flowering shrubs are the azalea, butterfly bush, camellia, gardenia, and Chinese hibiscus. Shrubs with attractive fruits include the natal plum and pyracantha. Red leaf, barberry, dusty miller, Texas sage, and poinsettia all have striking foliage color.

Shubert (family) Three brothers—**Lee Shubert**, b. Mar. 15, 1875, d. Dec. 25, 1953; **Sam S. Shubert**, b. 1876, d. May 12, 1905; and **Jacob J. Shubert**, b. Aug. 15, 1880, d. Dec. 25, 1964—dominated American theater management during the first half of the 20th century. After managing small theater companies in and near their native Syracuse, N.Y., in 1900 the brothers acquired the Herald Square Theatre in New York City, formed a theatrical company, and acquired theaters in many other cities to establish a national theater chain. Eliminating competition by an agreement (1914) with their major rival, they virtually monopolized American theater activities until the U.S. government instituted (1950) antitrust action against them. A theater named for Sam S. Shubert (opened 1913) on New York's 44th Street has housed many important productions.

shuffleboard In the game shuffleboard, players use long sticks with a U-shaped piece at one end to slide flat disks across a specially marked court. One player or team has 4 red disks, and the other has 4 black disks, that are 0.75–1 in (1.9–2.5 cm) thick and 6 in (15.2 cm) in diameter.

The shuffleboard court is 52 ft (15.8 m) long and 6 ft (1.8 m) wide; near each end is a base line from which the disks are played. Closer to the center from each end is a triangle divided into 6 sections with scoring and penalty values marked in each. In singles play the opponents stand at the same end of the court and alternately slide their disks from behind the base line to the scoring area at the opposite end. In doubles, two opposing players are at each end of the court, and all 8 disks are played first from one end and then from the other. A disk scores or is penalized according to the value of the section in which it comes to rest. A player may either try to land in a scoring section or try to displace an opponent's disk (and simultaneously land in a scoring section). A game may be to 50, 75, or 100 points.

Shultz, George P. George Pratt Shultz, b. New York City, Dec. 13, 1920, is an economist and public servant who held cabinet posts in two Republican administrations. Shultz was dean of the University of Chicago Business School before serving as secretary of labor (1969–70), director of the Office of Management and Budget (1970–72), and secretary of the treasury (1972–74) under President Richard Nixon. After heading the Bechtel Corporation, Shultz was President Ronald Reagan's very widely traveled secretary of state (1982–89).

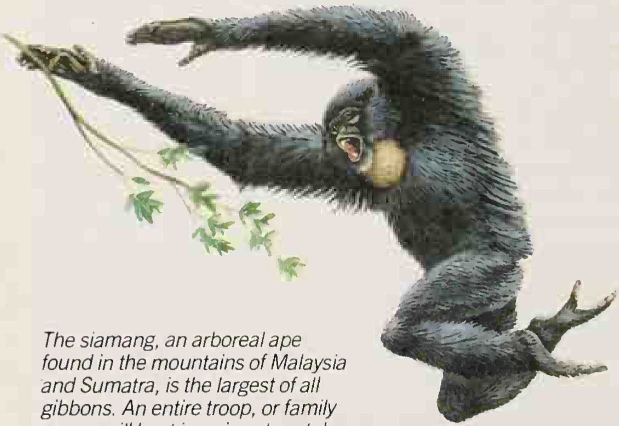
Shuswap [shoo'-swahp] A subdivision of the Interior SALISH, the Shuswap (or Sequapmuq) are a tribe of North American Indians that formerly held most of the territory around the Fraser, Thompson, and upper Columbia rivers, north of Shuswap Lake. They speak Shuswap, a Salishan dialect having structural similarities to the Algonquian-Wakashan language family. In the mid-19th century the Shuswap population was estimated at more than 7,000, but by 1912 they numbered only 2,100. The Shuswap now live on several small reservations in the Canadian province of British Columbia.

Traditionally, the Shuswap were seminomadic, living in portable mat-covered tents and lean-tos during the fishing and hunting seasons and in fixed settlements during the winter. Their permanent dwellings were semisubterranean structures formed of poles covered with mats and earth. Salmon was their staple food. Small extended families made up household units, and kinship was traced through both the father and the mother. Western groups borrowed the Coastal Salishan cultural pattern of having clans and classes of nobles, commoners, and slaves. Local bands were politically autonomous and were headed by inherited chieftainships.

Si Kiang see XI JIANG

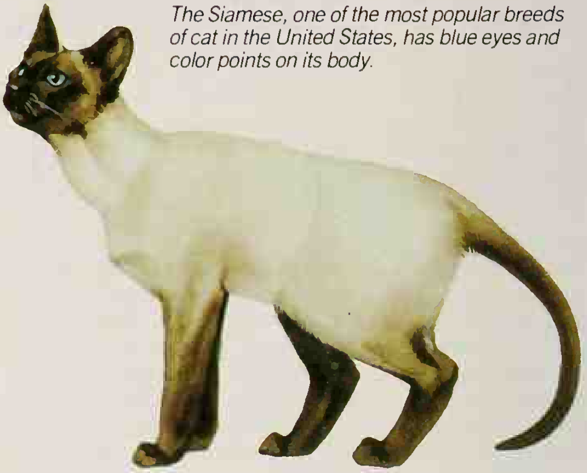
Siam see THAILAND

siamang [see'-uh-mang] The siamang, *Symphalangus syndactylus*, is a tree-dwelling ape in the GIBBON group of the family Hylobatidae. It lives in troops in mountainous regions of Sumatra and Malaysia. Webbing connects its second and third toes, and its throat has an inflatable air sac for loud hooting. The black-furred siamang may be 88 cm (35 in) tall and weigh up to 22.5 kg (50 lb). Its arm span is about 1.5 m (5 ft), and it has no tail. Siamangs feed mainly on fruit.



The siamang, an arboreal ape found in the mountains of Malaysia and Sumatra, is the largest of all gibbons. An entire troop, or family group, will hoot in unison to establish its claim to territory.

Siamese cat Siamese cats, a breed of shorthaired domestic cat, are muscular and agile, with a wedge-shaped head, slim legs, and a long, narrow tail. Their slanted blue eyes may be crossed, and they have a range of striking cries. Born partially albino, grayish cream in color, most Siamese develop "points," or darker colors, on their tail, muzzle, ears, legs, and feet: red (red point), dark brown (seal point), light brown (chocolate point), blue, gray, or lilac with a pink cast (lilac point).



The Siamese, one of the most popular breeds of cat in the United States, has blue eyes and color points on its body.

Siamese fighting fish Siamese fighting fish, *Betta splendens* (family Anabantidae), commonly called bettas, are native to waters of the Malaysian peninsula and Thailand. They have been cultured for many years, particularly in Thailand (Siam), where the aggressive males are pitted against each other and bets are placed. In wild fish and in fish bred for fighting, the fins are short. In European breeding, however, the original yellowish brown, faintly banded males were developed into a variety of long-finned, brightly hued individuals.

Siamese fighting fish have a complex courtship. The male first builds a nest of bubbles near the surface, each bubble being coated with mucus from his mouth. He then courts the female, gathers her eggs in his mouth, places them in the nest, and guards and cares for the eggs and the newly hatched fry.

The betta is one of the labyrinth fishes, so called because of the presence of labyrinths of folded tissue in two chambers in the gill cavity; these labyrinths can absorb

Siamese fighting fish are extremely aggressive toward each other. When males are placed together their colors deepen, and they spread their fins and gill covers, move side by side, and then attack—biting each other's fins, gills, eyes, and skin.

oxygen from air. Air breathing becomes a requirement some weeks after hatching, and bettas denied access to surface air will drown.

Siamese twins Siamese twins are identical twins who are joined, usually at the hip, chest, abdomen, or head, and who may share some organs. When both twins are relatively normal, they are termed symmetrical twins. When one child (the parasite) is underdeveloped and dependent on the normal child (the host), they are termed asymmetrical twins. Often, parasites are surgically removed so that the healthy host can survive. Successful separation of symmetrical twins has been performed, but it has rarely been attempted when vital organs are shared. Chang and Eng (1811–74), the original Siamese twins, remained joined but each eventually married and fathered several children.

See also: DEVELOPMENT, HUMAN; MULTIPLE BIRTH.

Sian see Xi'an

Sibelius, Jean [sib-ayl'-ee-us] Jean Sibelius, b. Dec. 8, 1865, d. Sept. 20, 1957, was Finland's greatest composer and a major postromantic musical figure. He trained for a career in law but then hoped to be a violin virtuoso. His studies, first in Helsinki, then in Berlin and Vienna, led him to composition. Back in Helsinki (1893), Sibelius became associated with a circle of artists and writers dedicated to Finnish cultural expression and political independence. Among his early patriotic works was his famous *Finlandia* (1899). From the Finnish national epic, the *Kalevala*, he drew inspiration for such orchestral works as the *Kullervo* Symphony (1892), the *Four Legends* (1893–95; including *The Swan of Tuonela*), and *Pohjola's Daughter* (1906).

He taught at Helsinki Conservatory until a government pension, granted in 1897, freed him for full-time composition. In 1902 he built a country home, Ainola, near Järvenpää, where he lived until his death. He became a national legend, and his birthdays were national festivals. He made only brief trips abroad, mainly to England and the United States, and taught at the New England Conservatory in 1914.

Sibelius developed a personal style of laconic concision, germinating rather than developing thematic material and carefully controlling orchestral color. The symphonic poem was an important vehicle for him, from *En Saga* (1893–1901), his earliest masterpiece, to the lean *Tapiola* (1925), his final major work. His seven symphonies (1899–1924), however, are his greatest works, and his violin concerto (1903) is a repertoire mainstay. He wrote many piano pieces and the string quartet called *Voces intimae* (1919). A composer of a number of songs (to both Finnish and Swedish texts) and choral works, he also made two unsuccessful attempts at opera.

The Finnish composer Jean Sibelius created a highly individual romantic musical style by integrating the spirit of Finnish nationalism with the German romantic tradition. His seven symphonies (1899–1924), for which he is best known, evoke haunting images of the Finnish landscape through intense orchestral harmonies and folk motifs.

Siberia Siberia is the Asian part of the Russian republic of the USSR. It extends from the Ural Mountains in the west to the Pacific Ocean in the east. Siberia is bounded on the north by the Arctic Ocean and on the south by China and Mongolia. Although its area is 12,800,000 km^2 (4,950,000 mi^2), or 57% of the USSR, its largely Russian population is disproportionately small and concentrated in a narrow belt along the Trans-Siberian Railroad.

West Siberia is a vast, swampy, forested plain drained by the Ob River and its tributary, the Irtysh River. East Siberia, east of the Yenisei River, is an upland; the easternmost part, including the Amur and Lena river basins, is often called the Soviet Far East.

Siberia has severe winters and warm summers except in the Far East. The mean annual temperature ranges from −18° to 4° C (0° to 39° F), and precipitation varies from less than 250 mm (10 in) to 500 mm (20 in).

In the 1980s development of the area's resource potential (petroleum, gas, coal, and metals) was spurred by the construction of the Baikal-Amur Mainline railroad and the Urengoi-Uzhgorod natural-gas pipeline.

The name *Siberia* (Russian: Sibir) was first applied in the 13th century to a Tatar khanate on the Irtysh River and was gradually extended eastward to the Pacific. Russian conquest of Siberia began with the expedition of the Cossack Yermak Timofeyevich in 1581–82 and continued through the 17th century. Siberian furs and, after 1700, minerals became a major source of wealth for the Russian Empire. From the early 17th century Siberia was also used as a penal colony.

Siberian husky The Siberian husky is a compact, powerful dog developed by the Chukchi tribe of extreme northeastern Siberia as an all-purpose sled dog. Leohard Seppala is credited with bringing the first team of huskies to Alaska in 1909, when sled-dog racing became popular. The breed was officially recognized by the American Kennel Club in 1930.

Male Siberians stand about 53 to 58 cm (21 to 23 in) at the shoulder and weigh 20 to 27 kg (45 to 60 lb); females are slightly smaller. Huskies have small, prick ears, a bushy, curled tail, and double coat. The topcoat is medium length and soft; the undercoat, thick and downy. The breed exists in a wide range of colors from black to white, with grays and reds frequently seen.

The Siberian husky, a medium-sized working dog native to northeastern Asia, is one of the fastest of all sled dogs.

sibyl [sib'-ul] In classical mythology sibyls were female prophets whose ecstatic utterances were inspired by Apollo. Early accounts refer to one individual, a famous prophetess of great age whose name was Sibylla. By the late 4th century BC, however, the name had become a title for as many as ten prophetesses. The sibyl of Cumae was said to have offered Tarquinius Superbus, one of the later kings of Rome, nine books of prophecies on Rome's destiny in return for half the king's fortune. When he answered that the price was too high, she burned three books and offered him the other six at the same price. Finally, she burned three more, and he paid the original price for the remaining three. The Sibylline books were placed in the Temple of Jupiter on the Capitoline Hill and were consulted in times of emergency.

Belief in the sibyls persisted into the early Christian era, when they were accorded an authority similar to that of the Old Testament prophets. A sibyl was credited with the Sibylline Oracles, a collection of Judeo-Christian writings now believed to date from about 150 BC to AD 180.

Sichwan (Szechwan) [sech'-wahn] Sichuan is a province of south central China, situated mostly north of the middle Chang Jiang (Yangtze River), which flows through its southern part. Sichuan—the most populous province of the country—has 107,218,173 inhabitants (1990). It is also one of the largest provinces, covering 569,000 km^2 (219,700 mi^2). The capital is Chengdu; Chongqing is the largest city and industrial center. Sichuan is mountainous in the north, west, and south; in the west the Xigang Plateau has an average elevation of about 4,500 m (15,000 ft.) The fertile Sichuan Basin in the east central portion—the most densely settled portion—is isolated from the rest of China by the mountains. More than one-third of the land is cultivated, and it is highly productive, because of the mild climate, adequate rainfall, and good drainage. Rice, wheat, peas, rapeseed, cotton, and sweet potatoes are grown. The mining of coal, iron, and copper supports industry in the cities. Sichuan was established as a province during the Qing dynasty (1644–1911). During the Second Sino-Japanese War (1937–45), Chongqing was the seat of the Chinese Nationalist government. Railroad lines built in the 1950s ended Sichuan's virtual isolation.

Sicilian Vespers The Sicilian Vespers—the revolt of the Sicilians against the rule of the Angevins—began at the time of vespers (evening worship) on Easter Monday, 1282, and resulted in the murder of almost the entire French population of Sicily. Partially a spontaneous outbreak against the oppressive regime of Charles I, Angevin ruler of Naples, the riot also stemmed from a conspiracy in which important foreign leaders, including Manuel II Palaeologus of the Byzantine Empire and Peter III of Aragon, moved to prevent Charles from invading the Byzantine Empire. In the resulting War of the Sicilian Vespers, Charles lost Sicily to the Aragonese.

Sicily The island of Sicily (Italian: Sicilia) with its neighboring islands forms a semiautonomous region of Italy. PALERMO is the capital. Separated from the southwest tip of the Italian peninsula by the Strait of Messina (see MESSINA, STRAIT OF), Sicily is surrounded by the Mediterranean Sea to the south, the Ionian Sea to the east, and the Tyrrhenian Sea to the north. Sicily has an area of 24,089 km^2 (9,301 mi^2); the region's population is 5,164,266 (1989 est.). The island is divided into nine provinces: Agrigento, Caltanisetta, Catania, Enna, Messina, Palermo, Ragusa, Syracuse, and Trapani.

The island's mountain chains are structurally a continuation of the Apennine Mountains. The highest elevation is atop Mount ETNA. The growing of wheat, citrus fruits, vegetables, olives, and grapes for wine, retailing, service, and civil-service occupations are important. Sicily's industries produce refined petroleum, ships, chemicals, pharmaceuticals, processed foods, fertilizers, sulfur, and other minerals. The island's main ports are CATANIA, MESSINA, and Palermo. Fishing dominates the coastal economy.

Sicily, the largest and most populous island in the Mediterranean, has been settled and ruled by many peoples. Its earliest-known inhabitants were the Elymi, Sicani, and Siculi. From the 8th century BC, Phoenicians, Carthaginians, and Greeks established settlements on the island. In the 5th century BC the leading Greek city, SYRACUSE, established hegemony over the other Greek colonies (including AGRIGENTO, GELA, Catania, Himera, and Messina). It faced a vigorous challenge from the Carthaginians, however, who by the end of that century controlled half the island. In the mid-3d century the Romans intervened against the Carthaginians on Sicily, precipitating the First PUNIC WAR (264–241 BC). After the Roman victory and the death of HIERO II of Syracuse, Rome gained control of most of the island.

Sicily was taken by the Vandals and then the Goths in the 5th century AD. In 532 it came under Byzantine rule, and in the 9th century it fell to the Muslim Arabs. The Arabs, who promoted both economic and cultural development, were driven out by the NORMANS in the late 11th century. The Norman ROGER II was recognized (1139) by Pope Innocent II as king of Sicily and of the Norman territories in southern Italy (see NAPLES, KINGDOM OF). Through the marriage of Constance, heiress of the last Norman king, to Holy Roman Emperor Henry VI, Sicily passed in 1194 to the Hohenstaufen dynasty. Their son, Holy Roman Emperor FREDERICK II, spent much of his time in Sicily, where, like Roger II, he effected important administrative reforms. After his death (1250), however, his weak successors were outmaneuvered by the papacy, which placed (1266) the Angevin CHARLES I on the throne as a papal vassal. Charles's oppressive rule provoked the Sicilian Vespers (1282), a revolt in which the Sicilians chose PETER III of Aragon as their king. Although the Aragonese secured control of Sicily, the Angevins retained Naples, and wars between the two continued until 1373.

The Aragonese allowed Sicily considerable local autonomy until the unification of Spain and the accession to the Spanish throne of the Habsburg dynasty (early 16th century). Sicily passed briefly to the house of Savoy (1713) and then to the Austrian Habsburgs (1720), but in 1734, during the War of the POLISH SUCCESSION, both Sicily and Naples were conquered by the Spanish Bourbon prince Charles. When Charles succeeded (1759) to the Spanish throne (as CHARLES III), Sicily and Naples passed to his son Ferdinand (see FERDINAND I, KING OF THE TWO SICILIES). The Bourbons ruled from Naples until the French forced Ferdinand to flee to Sicily in 1806. After the Napoleonic Wars, Ferdinand formally combined (1816) his realms as the Kingdom of the Two SICILIES. In 1860, Giuseppe GARIBALDI took Sicily, which ultimately became part of united Italy.

During World War II, Sicily was the scene of heavy fighting when the Allies launched an invasion from North Africa on July 9–10, 1943. The MAFIA developed there in the lawless conditions fostered by centuries of unpopular foreign rule.

Sickert, Walter Richard [sik'-urt] The English painter Walter Richard Sickert, b. May 31, 1860, d. Jan. 22, 1942, is known for his depictions of lively music-hall scenes (he began his career in the theater) and London interiors and for his numerous portraits. As a member of the art worlds of both London and Paris, Sickert helped to keep England in touch with developments on the Continent. He was made a royal academician in 1934. Many of Sickert's writings were published in *A Free House* (1947).

sickle-cell disease [sik'-ul-sel] Sickle-cell disease, also called sickle-cell anemia, is a genetic disease characterized by an abnormal form of HEMOGLOBIN, the oxygen-carrying protein of red BLOOD cells. Offspring of parents who both carry the gene controlling formation of this sickle-cell hemoglobin (HbS) develop the disease. When oxygen levels drop, HbS crystallizes and forms a rod shape, causing red blood cells to stiffen and distort into sicklelike shapes. These cells tend to clog capillary blood vessels and impede blood flow, producing pain in bones, muscles, and the abdomen and leading to shortness of breath and damage to internal organs.

In the United States, sickle-cell disease affects primarily blacks, but it also occurs in some individuals of Mediterranean, Middle Eastern, and East Indian descent. An estimated 60,000 American blacks suffer from the disease, and about 2.5 million of the nation's 30 million blacks carry the HbS gene. About 40 percent of the hemoglobin in these carriers is HbS. Whereas most carriers lack symptoms, under extreme stress when blood oxygen is depleted, such as in strenuous exercise, carriers may be prone to collapse and possible death. Prospective parents can now be screened to determine if they are carriers of the sickle-cell gene.

Treatment involves pain relievers and antibiotics, and sometimes blood transfusions are required. Bone-marrow transplants have been successful but also have a high degree of risk. New treatments are being developed that ease the symptoms of the disease. Clinical trials are under way on the drug hydroxyurea, which increases the body's production of hemoglobin that resists distortion. Hydroxyurea is also being administered in combination with erythropoietin, a hormone that stimulates red-blood-cell production.

Sickles, Daniel Edgar [sik'-ulz] Daniel Edgar Sickles, b. New York City, Oct. 20, 1825, d. May 3, 1914, a Union military leader during the Civil War, served (1857–61, 1893–95) in Congress and was military governor of the Carolinas (1865–67) and minister to Spain (1869–73). In 1859, Sickles killed a man who was allegedly having an affair with his wife. Sickles was acquitted on a plea of temporary insanity, the first time this defense was used in a U.S. court.

Sicyon [sish'-ee-ahn] Sicyon was an ancient Greek city in the Peloponnesus located on a plain northwest of Corinth and just below the Gulf of Corinth. Founded by Argos, it reached the peak of its power under CLEISTHENES in the early 6th century BC. After Cleisthenes' defeat, Sicyon was allied with Sparta, and in the 3d century BC it joined the Achaean League. A major artistic center in the Archaic period (625–480 BC), Sicyon was renowned during the 4th century BC for its school of painting, which produced such artists as APELLES and Pamphilus. The sculptor LYSIPPUS also worked in Sicyon.

Siddons, Sarah [sid'-uhnz] The eldest child of the actor-manager Roger Kemble (see KEMBLE family) and the wife of the actor William Siddons, Sarah Siddons, b. July 5, 1755, d. June 8, 1831, was one of the greatest tragediennes of the English stage. After touring the provinces and making (1775) an unsuccessful London debut, she finally triumphed (1782) as Isabella in *The Fatal Marriage*. Admired by Samuel Johnson and William Hazlitt and painted by Sir Joshua Reynolds as *The Tragic Muse*, Mrs. Siddons found her greatest role as Lady Macbeth.

sidereal time see DAY

siderite [sid'-ur-ite] The iron CARBONATE MINERAL siderite ($FeCO_3$) was formerly a major ore. It forms gray-to-brown rhombohedral crystals (hexagonal system) in silver-ore veins, compact concretions called clay ironstone in clay or shale deposits, and impure earthy material stratified with coal deposits called black-band ore. Hardness is 3½ to 4, streak is white, and specific gravity is 3.8 to 3.9. The most valuable siderite ore is mined from limestone deposits in Austria.

Sidewinder Sidewinder is an air-to-air missile that entered operational service in 1956. Thousands have been supplied to the air forces of more than 20 countries, and licensed production in Europe for NATO alone has accounted for at least 9,000 Sidewinders. Manufactured in several versions, all have been infrared (heat-seeking) homing missiles except the AIM-9C, which has a semiactive radar homing head. Improvements have continued to be made to Sidewinder subsystems, including the guidance and electronics, the warhead, and the propulsion motor. Dimensions vary slightly from model to model, but the latest (AIM-9L) is 2.8 m (9.4 ft) long and 12.7 cm (5 in) in diameter. Weight is about 86 kg (190 lbs). The main operational role is for air-combat missions. Typical range is between 5 and 16 km (3 and 10 mi). A land-based version, known as Chaparral, is employed for mobile short-range air defense.

See also: ROCKETS AND MISSILES.

sidewinder The sidewinder, *Crotalus cerastes*, is a RATTLESNAKE found in mostly sandy, arid areas from southern California and Nevada to Sonora, Mexico. It received its name from its sidewinding locomotion—an efficient method for escaping over soft sand by looping the body forward in the shape of an S that contacts the ground at only two points, then "rolling" each loop ahead by shifting those points of contact back along the length of the body, by which means the snake may reach a top speed of about 4 km/h (2.5 mph). Sidewinders average less than 60 cm (2 ft) long, but some may exceed 75 cm (2.5 ft). They are generally a sandy color with grayish or brownish blotches, and the scale above each eye is developed into a hornlike projection. Sidewinders are primarily nocturnal and feed on lizards and small rodents.

Sidgwick, Henry [sij'-wik] An English philosopher best known for his ethical studies, Henry Sidgwick, b. May 31, 1838, d. Aug. 29, 1900, was a professor of philosophy at Cambridge University. His most important philosophical work was *The Methods of Ethics* (1874), generally regarded as one of the most significant works on moral theory in the English language. Although critical of older utilitarians such as Jeremy Bentham and John Stuart Mill, Sidgwick produced a thorough formulation of the utilitarian position that actions are right or wrong on the basis of their conformity with the general welfare. His primary argument for UTILITARIANISM was that it best described the morality of ordinary common sense.

Sidney, Algernon Algernon Sidney (or Sydney), b. 1622, d. Dec. 7, 1683, was an English republican politician and theorist. He fought for Parliament in the English Civil War. During the Commonwealth (1649–53), Sidney became an opponent of Oliver CROMWELL's dictatorship; he lived mostly in retirement during the Protectorate (1653–59). After the restoration of King Charles II (1660), Sidney lived abroad until permitted to return in 1677, when he became enmeshed in anti-Stuart politics.

Following the Rye House Plot (1683) to foment a Scottish rebellion, Sidney was tried, convicted of high treason—on dubious evidence—and executed. His posthumously published *Discourses concerning Government* (1698) became a popular tract of republican political theory.

Sidney, Sir Philip Renowned in his day as the English Renaissance courtier par excellence, Sir Philip Sidney, b. Penshurst, Kent, Nov. 30, 1554, d. Oct. 17, 1586, is now remembered primarily for his literary achievements, especially *An Apologie for Poetrie* (1579–81; publ. 1595), also known as *The Defence of Poesie*, the first English essay of literary criticism; the sonnet sequence *Astrophel and Stella* (1575–83; publ. 1591); and the prose romance *Arcadia* (1580–83; publ. 1590 and, with revisions, 1593, 1598).

After attending (1568–71) the University of Oxford and traveling (1572–75) in Europe, Sidney attended the court of Elizabeth I, sat in Parliament (1581–86), supervised coastal defense, and served in the army. Always eager for new challenges, he accepted appointment in 1585 in the Low Countries as governor of Flushing. He was wounded in a skirmish with the Spaniards at Zutphen and died three weeks later. His death occasioned a month of mourning in England.

Although Sidney's works were not printed during his lifetime, they circulated widely in manuscript. His *Apologie*—a response to two attacks by Stephen Gosson on stage plays—argues that literature provides the highest form of human learning because it moves readers most effectively toward wisdom. *Astrophel and Stella* demonstrates how to contain the rhythms of speech within the patterns of meter, creating poems that are both forceful and lyrical. Strongly influenced by 16th-century Spanish and Italian romances, *Arcadia* proved that the English vernacular could sustain the heroic and pastoral modes of classical and Italian literature.

Sidon [sy'-duhn] Sidon was a city in ancient PHOENICIA situated on the upper Palestinian coast near modern Beirut. It survives today as Saida, a Lebanese town of about 50,000 persons.

With TYRE, Sidon symbolized Phoenician maritime enterprise, attaining prominence (*c.*1300 BC) as a trading center. By the 9th century BC, however, it had become a dependency of Tyre and, like all Phoenician cities, was at the mercy of the great Near Eastern powers, thriving or suffering according to its willingness to pay tribute. Thus Sidon was destroyed (677 BC) by Esarhaddon of Assyria. The city was rebuilt, but it declined under the Babylonians and was later revived (after 539 BC) by the Persians. Sidon's sailors were among the Phoenician naval contingents during the Battle of Salamis (480 BC). In 351, Sidon was burned following a revolt against Persia. Eighteen years later, Sidon surrendered to Alexander the Great without a fight. The city later became famous for its glassware and purple-dye industries.

Siegfried [sig'-freed] In medieval German literature Siegfried was the hero of the NIBELUNGENLIED, a famous poem composed *c.*1200. He possessed a cape that gave him the power to become invisible and a wondrous sword called Balmung. As a youth he had bathed in the blood of a dragon, which rendered his body safe from wounds, except for the spot on his back where a linden leaf had fallen while he was bathing.

Siegfried went to the city of Worms and wooed Kriemhild, sister of the Burgundian king Gunther. Gunther, however, wished to court the Valkyrie BRUNHILD, and he asked the young hero to help him. Aided by his magical powers, Siegfried secured Brunhild for his future brother-in-law and married Kriemhild, and all went well until Brunhild discovered that it was Siegfried, not Gunther, with whom she had slept on her wedding night. Angered by this discovery, Brunhild persuaded Hagen—one of Gunther's retainers, who had discovered the fact that Siegfried had a vulnerable spot—to kill the unsuspecting hero and to steal the treasure of the Nibelungs, which Siegfried had obtained many years earlier.

The Old Norse counterpart of Siegfried was Sigurd the Volsung, hero of the *Volsungasaga* (see ICELANDIC LITERATURE).

Siena [syen'-uh] Siena, the capital city of Siena province in the Tuscany region of north central Italy, is situated about 55 km (35 mi) south of Florence. It has a population of 59,712 (1987 est.). The city produces wine, fertilizer, and chemicals. Siena has largely retained the appearance of a large, prosperous medieval city. Among its most notable landmarks are the 13th- and 14th-century Gothic Palazzo Pubblico, the Gothic-Romanesque cathedral, and the 14th-century Gothic Baptistery of San Giovanni. Many medieval and Renaissance palaces also survive. The University of Siena dates from the 13th century.

Founded by Etruscans and later ruled by Rome and the Lombards, Siena became a free commune in the 12th century. In the 13th century it became a flourishing banking center rivaling Florence. The 13th- to 14th-century Sienese school of painting, which produced artists such as DUCCIO DI BUONINSEGNA, ended when the Black Plague began (1348). Emperor Charles V halted Siena's four centuries of republican autonomy in 1555. In 1569 the city came under the Medici dukes of Tuscany, and Siena thereafter shared the history of Tuscany, joining united Italy in 1860.

Sienkiewicz, Henryk [shen-kyeh'-veech] Poland's first winner (1905) of the Nobel Prize for literature, Henryk Sienkiewicz, b. May 6, 1846, d. Nov. 5, 1916, is best known internationally for his novel about ancient Rome and early Christianity, *Quo Vadis?* (1895–96; Eng. trans., 1896). His most popular work in Poland is a trilogy of colorful historical novels, about Poland's wars during the 17th century, comprising *With Fire and Sword* (1883–84; Eng. trans., 1890), *The Deluge* (1884–86; Eng.

trans., 1891), and *Pan Michael* (1887–88; Eng. trans., 1893).

Sierra Club [see-air'-uh] The Sierra Club is a national organization devoted mainly to participation in wilderness activities such as mountain climbing, backpacking, and camping and to protection of wilderness environments through political action. It was founded on June 4, 1892, by a group of 162 Californians, primarily university-trained individuals and faculty members, with John Muir as president. The Sierra Club thus gave formal expression to a distinctly Californian relationship—both intellectual and sensual—to the outdoors. An early major achievement of the organization was the preservation of the Yosemite as a national park. Today its membership comes from many states.

Sierra Leone [see-air'-uh lee-oh'-nee] Sierra Leone is a republic in western Africa, bordered by Guinea on the north and east, Liberia on the southeast, and the Atlantic Ocean on the southwest. Sierra Leone gained independence from Britain in 1961. Freetown is the captial.

Land and Resources

A swamp about 50 km (30 mi) wide borders the coast. In the interior this marsh gives way to a plain covered by tall grasses and sparse forests. Further east is a region of plateaus and mountains, which reach an elevation of 1,948 m (6,390 ft) at Mount Lomas, the highest point in the country. The mountainous Sierra Leone Peninsula, the western coast, juts into the ocean, sheltering Freetown and forming its magnificent harbor—the third largest in the world. The country's soil is not very fertile. Most of the original forest cover has been cleared for agriculture; sizable oil palm forests now constitute a secondary growth. Animal life includes monkeys, lions, leopards, hippopotamuses, and many species of insects, birds, and fish.

The climate is tropical, with a rainy season from May to October. Temperatures average 20° to 30° C (68° to 86° F), but variation is slightly greater in the highlands. Annual precipitation ranges from 2,030 mm (80 in) in the northeast to more than 3,810 mm (150 in) on the peninsula. The major rivers of Sierra Leone include the Great and Little Scarcies (called the Kolente and Kaba in Guinea), the Rokel, Jong, Waanje, Sewa, Moa, and Mano, most of which rise in the Guinea highlands to the east and flow southwest to the Atlantic.

People

Although the indigenous people share many institutions, their languages fall into two groups, suggesting separate origins. The Mande category encompasses Mende, spoken by the country's largest ethnic group, a people who live in the south and east. Peoples speaking related languages include the Susu, Loko, and Kono. The West Atlantic family includes Temne, the language and name of

AT A GLANCE

REPUBLIC OF SIERRA LEONE

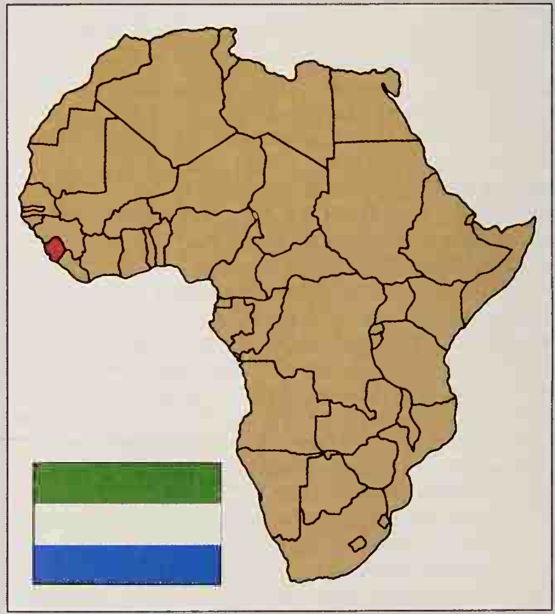
Land: Area: 73,326 km^2 (27,925 mi^2). Capital and largest city: Freetown (1985 est. pop., 496,776).

People: Population (1990 est.): 4,165,953. Density: 57 persons per km^2 (149 per mi^2). Distribution (1985): 28% urban, 72% rural. Official language: English. Major religions: traditional religions, Islam, Christianity.

Government: Type: one-party state. Legislature: House of Representatives. Political subdivisions: 3 provinces, Western Area.

Economy: GNP (1989): $813 billion; $200 per capita. Labor distribution (1986): public administration and services—32%; trade and transportation—17%; construction—12%; manufacturing—12%; mining—8%; agriculture (wage earners)—8%. Foreign trade (1988): imports—$167 million; exports—$106 million. Currency: 1 leone = 100 cents.

Education and Health: Literacy (1985): 29% of adult population. Universities (1988): 2. Hospital beds (1983): 4,754. Physicians (1984): 262. Life expectancy (1990): women—47; men—42. Infant mortality (1990): 154 per 1,000 live births.



the second largest ethnic group, whose homeland is in the central and western regions. The Limba, Kissi, Bulom or Sherbro, and Muslim FULANI cattle keepers in the far north all speak related languages. The Creoles, descendants of freed black slaves, form a third category concentrated in Freetown and the west. They speak Krio, a hybrid trade language derived from English and various African languages. There are also many refugees from war-torn neighboring Liberia. A majority of Sierra Leoneans follow traditional religions. About 40% are Muslims, and there is a large Christian minority.

Emigration from rural areas to the towns, common throughout Africa but particularly pronounced in Sierra Leone, has made Freetown and the peninsula the most densely settled part of the country; cash crops and mining have also attracted people to the east. The literacy rate, which rose after independence, has declined in recent years. There are two universities—the University of Sierra Leone (1967), incorporating Fourah Bay College (1827), and Njala University College (1963).

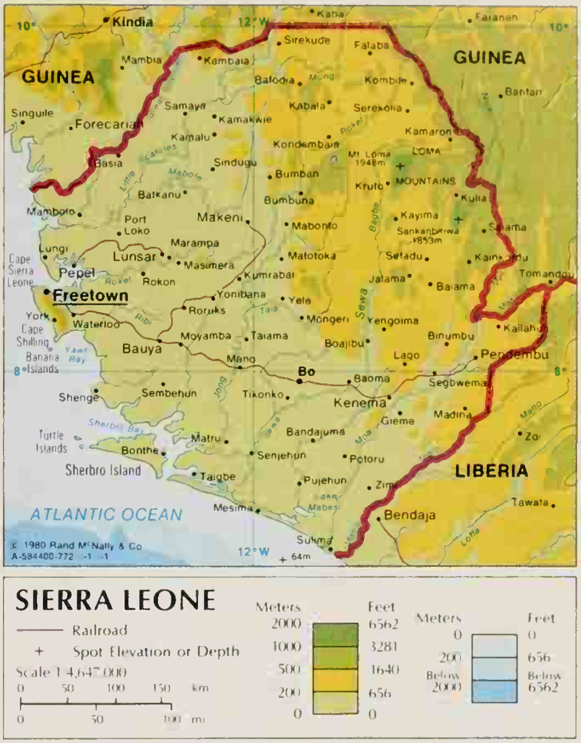
Economic Activity

Sierra Leone possesses a dual economy whose sectors are not well integrated. The export economy is dominated by extractive industries (diamonds, bauxite, and titanium dioxide) that employ few people but provide 85% of foreign exchange. The main food crops are rice, cassava, sorghum, and millet. Export crops include coffee, cocoa, palm kernels, groundnuts, ginger, and fruits and vegetables. Tropical woods are harvested for domestic use, and ocean fishing is of growing importance. In the early 1990s the economy was battered by shortages, inflation, and a flourishing black market.

History and Government

The Temne probably inhabited present-day Sierra Leone by the 12th century. Divided into small chiefdoms, they inhabited the coast in the 15th century when Europeans first reached sub-Saharan Africa. The Mende moved into the area from the northern savanna during the same period. Creole history begins in 1787 when British opponents of the slave trade founded a colony for freed slaves on the coast that ultimately became Freetown. By 1850 more than 50,000 former slaves originally from many parts of Africa had resettled there. The provision of churches and schools helped mold a common Creole culture, and these immigrants soon dominated coastal affairs. In 1896 the hinterland became a British protectorate, although the coastal area remained a colony, a division that emphasized differences between the Creoles and indigenous peoples and hindered the emergence of a common national identity after the country gained independence.

Siaka Stevens, who headed the government from 1968 until his retirement in November 1985, did much to unify the country. By the 1980s, however, his government faced growing opposition due to rising prices, food shortages, and fiscal scandals. In 1985 the All People's Congress (the only legal political party from 1978 until the adoption of a multiparty constitution in 1991) selected army chief of staff Maj. Gen. Joseph Saidu Momoh to succeed the aging Stevens. Stevens retained the key post of party leader until his death in 1988. Liberian rebels led by Charles Taylor invaded Sierra Leone in 1991, angered by Momoh's support for the West African peacekeeping force in Liberia. Momoh reluctantly acceded to domestic demands for political reform, but he was ousted by dissident soldiers in 1992. The 1991 constitution was suspended. Capt. Valentine Strasser, head of the new National Provisional Ruling Council, pledged to end the rebel war, halt corruption and mismanagement, rebuild the economy, and restore constitutional democracy.



Sierra Madre [see-ay'-rah mah'-dray] The Sierra Madre ("mother range" in Spanish), a volcanic, forested mountain system, occupies 75% of the area of Mexico. It extends 2,415 km (1,500 mi) from the Rio Grande to the Isthmus of Tehuantepec and includes the Sierra Madre Occidental, Sierra Madre Oriental, and Sierra Madre del Sur. The average elevation is about 2,700 m (8,860 ft). The rugged Sierra Madre Occidental, parallel to the Gulf of California, is 1,290 km (800 mi) long and 485 km (300 mi) across at its widest part. The Sierra Madre Oriental, parallel to the Gulf of Mexico coast, is about 1,125 km (700 mi) long, and the Sierra Madre del Sur occupies southern Mexico from the Pacific coast to the Isthmus of Tehuantepec. The highest peak of the Sierra Madre is Orizaba in the Sierra Madre Oriental (5,747 m/18,855 ft), and the most famous mountains are POPOCATÉPETL and IXTACIHUATL in the central plateau. The mountains contain major deposits of silver and copper.

Sierra Nevada (Spain) [see-ay'-rah nay-vah'-dah] The Sierra Nevada ("snowy range" in Spanish), the highest mountain range in Spain, extends about 100 km (60 mi) from east to west through the provinces of Granada and Almería, roughly parallel to the Mediterranean Sea, which is only 32 km (20 mi) to the south. The highest peak, Mulhacén (3,478 m/11,411 ft), is permanently snowcapped, and Europe's southernmost glaciers are located in the range. Grapes, olives, and sugarcane are grown on the southern slopes, and lead, zinc, copper, and iron are mined.

Sierra Nevada (United States) [see-air'-uh nuh-vah'-duh] The Sierra Nevada is a mountain range in eastern California, running from the Mojave Desert and Tehachapi Mountains northwest for about 640 km (400 mi) to the Cascade Range. The range has an average width of 100 km (60 mi) and reaches a maximum of 130 km (80 mi). A geologically young range composed primarily of granite, the mountains present an abrupt face to the east and a sloping aspect to the west. The west side receives most of the precipitation and as a result is sculptured by glaciers and streams. Major rivers include the Feather, Yuba, American, Merced, and Kern.

The highest peaks are in the south, in the region known as the High Sierra. Of these pinnacles, Mount Whitney (see WHITNEY, MOUNT) is the highest mountain in the conterminous United States. The peaks attract climbers and skiers, and fishing, hiking, and camping are also popular. YOSEMITE NATIONAL PARK, Sequoia National Park, and Kings Canyon National Park draw tourists, as do several national forests. Besides tourism, lumbering is a major industry. Sighted by explorers as early as 1772, the Sierra Nevada gained fame after the discovery of gold there in 1848.

Sieyès, Emmanuel Joseph [see-ay-es'] Emmanuel Joseph Sieyès, b. May 3, 1748, d. June 20, 1836, a cleric and revolutionary theorist, contributed both to the beginning and to the ending of the FRENCH REVOLUTION. His pamphlet *Qu'est-ce que le tiers état?* (What Is the Third Estate?), published in January 1789, asserted that the commoners (the third estate)—and not the privileged nobles and clergy—should lay the foundations of a new order in France. This classic statement of the revolutionary doctrine was immensely influential, and as a deputy for Paris, Sieyès was also primarily responsible for the decree (June 17, 1789) establishing the National Assembly as a sovereign body. In 1799, after becoming a member of the DIRECTORY, he used his position to arrange the coup d'état of 18–19 Brumaire (November 9–10), by which he, Pierre Roger Ducos, and Napoléon Bonaparte overthrew the Directory. As Bonaparte swiftly consolidated his own authority, Sieyès was relegated first to the Senate and then to well-endowed retirement.

Siger de Brabant [see-zhay duh brah-bahn'] A professor of philosophy at the University of Paris, Siger de Brabant, *c.*1235–*c.*1284, was the foremost Latin Averroist—an Aristotelian philosopher who regarded the Islamic philosopher AVERROËS as the greatest commentator on Aristotle—of his time. Siger maintained that philosophy demonstrates the impossibility of personal immortality, but that we know from faith that personal immortality is nevertheless possible. Critics such as Saint Thomas Aquinas and Saint Bonaventure accused him of holding a doctrine of "double truth."

Sigismund, King of Germany and Holy Roman Emperor [sig'-is-muhnd] Sigismund, b. Feb. 15, 1368, d. Dec. 9, 1437, was the last of the Luxemburg dynasty of Holy Roman emperors. He inherited (1378) Brandenburg from his father, Emperor CHARLES IV, and became king of Hungary (1387) through marriage to the Hungarian princess Mary. Sigismund's crusade against the Turks was defeated (1396) resoundingly at Nicopolis. In 1400 he helped depose his half brother, Emperor WENCESLAS, and in 1410–11 procured his own election as German king.

In his greatest contribution to European Christendom, Sigismund facilitated the organization of the Council of Constance (1414–18) and the resignation of "Antipope" JOHN XXIII, thus ending the Great SCHISM of 1378–1415. His refusal at the council to protect the condemned heretic John Huss caused Sigismund much grief after he became Bohemian king (1419) and was drawn into the Hussite Wars. A new crusade (1426–27) against the Turks also ended in defeat. Sigismund was crowned Holy Roman emperor in 1433.

In bestowing the electorate of Brandenburg on the Hohenzollern princes and that of Saxony on the Wettin family, Sigismund elevated two dynasties that flourished in Germany until 1918. Before his death he arranged for the succession of his titles to his son-in-law, Albert II, thus passing the crown of the Holy Roman Empire to the Habsburgs.

Sigismund I, King of Poland Sigismund I (the Old, or the Great), b. Jan. 1, 1467, d. Apr. 1, 1548, was king of Poland (r. 1506–48) when the country was a great power. During his reign the Renaissance and Reformation reached Poland, and he presided over the first golden age of Polish literature.

A monarch of the JAGELLO dynasty, he succeeded his brother Alexander I (r. 1501–06). Sigismund lost (1514) Smolensk to Russia but imposed (1525) Polish sovereignty on East Prussia and incorporated (1529) Mazovia. Hoping to strengthen Poland, he arranged (1515) a marriage compact with the Austrian Habsburgs, and in 1533 he concluded peace with the Ottoman Turks. A Catholic, he nevertheless granted religious freedom to Protestants and accorded royal protection to Jews, thereby making Poland the most tolerant state in Europe. He was succeeded by his son Sigismund II.

Sigismund II, King of Poland Sigismund II Augustus, b. Aug. 1, 1520, d. July 7, 1572, last Polish king of the JAGELLO dynasty, reigned (1548–70) at the peak of Poland's golden age. Succeeding his father, Sigismund I, he created the unified Polish-Lithuanian state, granting Albert (Hohenzollern), elector of Brandenburg, hereditary rights to East Prussia in return for his recognition of Polish sovereignty (see ALBERT, 1ST DUKE OF PRUSSIA). The war (1557–71) with IVAN IV of Russia over LIVONIA forced Sigismund to consolidate his kingdom. Playing off the Polish gentry against the Lithuanian magnates, he secured (1569) the Union of Lublin, which legally united Poland, Lithuania, Ducal Prussia, and Livonia. Although Sigismund accepted (1564) the resolutions of the Council of Trent (the Catholic Counter-Reformation), he continued his father's policy of religious toleration in Poland. By the time of his death, more than half of the Polish nobles were Protestant, but a return to Catholicism had begun with the establishment of Jesuit schools in the kingdom in 1564. The Polish crown became elective after Sigismund's death because he left no male heir.

Sigismund III, King of Poland Sigismund III Vasa, b. June 22, 1566, d. Apr. 20, 1632, was king of Poland (1587–1632) and Sweden (1592–99). Son of John III Vasa of Sweden and Catherine Jagello of Poland, Sigismund, a devout Catholic, succeeded his uncle Stephen Báthory as king of Poland. He ascended to the Swedish throne after his father's death, but his refusal to accept Protestantism as Sweden's state religion led to his deposal. Sigismund involved Poland in 30 years of war with the Swedes, culminating (1629) in his loss of most of Polish Livonia. During the TIME OF TROUBLES in Russia, he established his son Władysław on the throne there, but Sigismund's goal of personally ruling Russia led to the expulsion of the Poles and the accession (1613) of the Romanov dynasty.

Sigismund helped establish (1596) the Uniate church, uniting the Orthodox Ruthenians with the Roman Catholic church. He transferred the capital to Warsaw and patronized the arts. As a result of his lengthy wars, however, Poland declined as an international power. Sigismund was succeeded by his sons, Władysław and then John II.

sign language Sign language is the use of gesture as the medium of communication. Not all gestures are examples of sign language; only those showing a degree of systematic organization comparable to that of spoken language qualify as signs. Many signs are iconic in that some similarity exists between the sign and what it refers to, but the form of most signs is arbitrary.

Of the many sign languages employed by deaf-mutes, some, including American Sign Language (ASL), or Ameslan, are based on a system developed in France in the 18th century. Many American deaf-mutes also learn Signed English, in which, unlike Ameslan, the order of signs parallels English word order. Written words can also be spelled out by the finger positions of the so-called manual alphabet.

The Indians of the Great Plains of North America, speaking a wide variety of languages, developed a sign system that permitted communication between members of different tribes. Signs are also used by monks under a vow of silence. In recent years, signs have been used with good results in breaking through the psychological isolation of autistic children. Ameslan has also figured in training chimpanzees to communicate with humans.

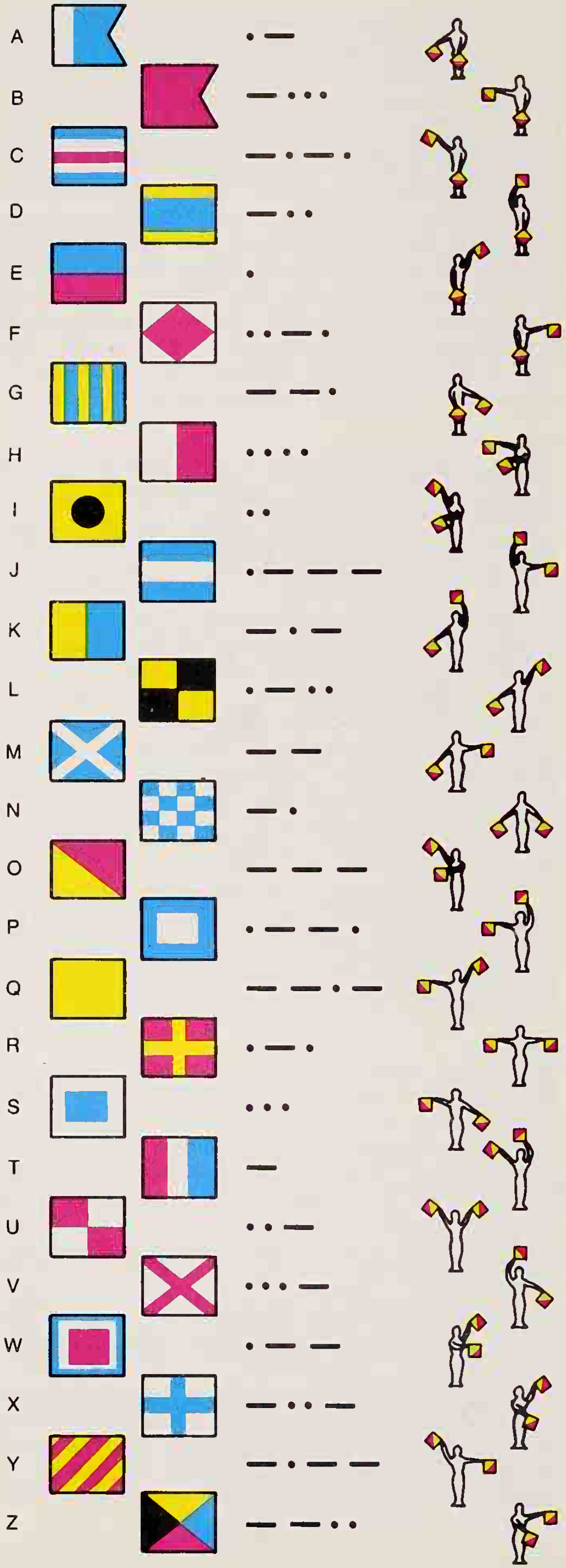
Signac, Paul [seen-yahk'] One of the principal neoimpressionist painters, Paul Signac, b. Nov. 11, 1863, d. Aug. 15, 1935, worked with Georges SEURAT in creating pointillism (or divisionism). Signac published *From Delacroix to Neo-Impressionism* (1899), explaining their theories.

Signac taught himself to paint by studying the works of Claude Monet and others. After he and Seurat met in 1884, they developed their technique of painting with dots—or *points* in French—of color, which led to the name *pointillism.* As Signac explained, they used the pure impressionist palette but applied it in dots that were to be blended by the viewer's eye. What Signac called "muddy mixtures" were to be banished from painting and replaced by luminous, intense colors. Many of Signac's works are landscapes; he also painted some figure compositions.

The neoimpressionists influenced the next generation; Signac inspired Henri Matisse in particular. As president of the annual Salon des Indépendants (1908–34), Signac encouraged younger artists by exhibiting the controversial works of the Fauves and the cubists.

signaling Signaling is the transmission of information by means other than the unaided human voice (see also ANIMAL COMMUNICATION; COMMUNICATION). Signals, which can be visual, audible, or electrical, can be made by a variety of means, including lighted torches, smoke, flags, lamps, drums, guns, telegraph, telephone, and radio. Electrical signals can be transmitted very quickly over great distances and are known as TELECOMMUNICATIONS. Signals are used to control railroad trains and vehicular traffic on roads and highways (see TRAFFIC CONTROL) and to communicate with ships, airplanes, and other vehicles. The term *signaling* also applies to systems of military communication.

Military Signaling. Military signals may be considered extensions of the commander's voice. Since earliest times commanders have called out orders to their troops. Smoke signals were employed by Hannibal, the Carthaginian general who lived two centuries before



(Left) *Code systems supply a visible or audible equivalent for each letter of the alphabet. Messages can be transmitted between ships at sea by means of the present International Flag Code* (left), *in use since 1934. Telegraph communications utilize the International Morse Code* (center), *in which each letter is indicated by a specific combination of short and long signals. This code is also used at night by ships that have searchlights with shutters. The signaling pattern of semaphore* (right) *is based on the positions of clock hands.*

Christ, and by the native Indians of the United States.

Audible signals used during military history have included trumpets, horns and tubas (Julius Caesar), and bugles (Napoleon). Genghis Khan had whistling arrows, which he fired toward the enemy to direct his archers. The modern counterpart of these arrows is the tracer bullet, which makes both an audible and visual signal.

Wigwag, a semaphore system of signal communication, was invented in the United States during the 19th century and used in the Civil War. The signals were given by means of flags that were waved according to a prearranged pattern.

With the electric telegraph, invented by Samuel F. B. Morse, sending and receiving messages over long distances at great speed became possible. The Morse code, in which combinations of long and short signals indicated alphabet letters, numbers, and punctuation, was developed for use over the electric telegraph. In the 1940s radios were developed that transmitted and received voice and Morse-code messages through the air.

Marine Signaling. The first recorded use of a marine signaling system was that of the Spanish navy early in the 16th century. In 1799, Britain's Royal Navy began to use a printed signal book that allowed any ship to communicate with any other. This system involved alphabetical and numerical flags that were hoisted above the deck so that they could be read at a distance. Other nations soon developed their own flag signals for naval and merchant seacraft. The First International Code Signals were published in 1857. They were revised and expanded twice before the present system came into use on Jan. 1, 1934. To supplement flag systems, ships carry searchlights with shutters that are used to flash messages in Morse code. When visibility is poor, an international system of horn signals may be used. Vessels also make use of a semaphore system and the two-way radiotelephone, which carries a voice message.

Other Types of Signaling Devices. Although voice radio messages are the most common form of communication between aircraft and the ground, they are supplemented by visual signals, such as flashing lights at airports. Railroad trains are controlled both by radio and by semaphore systems. Vehicular traffic is guided and alerted by visual signals in the form of highway signs with international symbols, and the familiar traffic signals with red, yellow, and green lights. Emergency vehicles signal their presence to other vehicles by the use of flashing lights and sirens.

Signorelli, Luca [seen-yoh-rel'-ee] Luca Signorelli, b. *c.*1445, d. Oct. 16, 1523, was among those Tuscan artists committed to the Renaissance goal of scientifically rationalizing space and the human figure. His *Realm of Pan* (*c.*1488; destroyed 1945) corresponded to Antonio Pollaiuolo's experiments in depicting human motion; Signorelli's painting also employed the mythological iconography of Pollaiuolo and Sandro Botticelli. Signorelli's fresco decorations rank among the finest of such paintings made in central Italy in the 1480s and 1490s. His *Death of Moses* (1482) in the Sistine Chapel attests to his skill; even more important is his vast fresco cycle (1499–1504) in the Chapel of San Brizio of the Orvieto Cathedral. It depicts the world's end, beginning with the *Preaching of the Anti-Christ* and continuing through scenes of hell, purgatory, and heaven. The physical and iconographic scale, as well as the large number of nudes, prepared the way for the Roman frescoes of Michelangelo and Raphael.

Sigurd see SIEGFRIED

Sigurdsson, Jón [sik'-urth-sohn, yohn] The great Icelandic patriot Jón Sigurdsson, b. June 17, 1811, d. Dec. 7, 1879, was a leader in the transformation of Iceland from a Danish province into a self-governing country united with Denmark. As scholar, editor, and organizer of learned societies, Sigurdsson helped to stimulate a cultural renaissance in Iceland and to revive the Icelandic parliament (Althing) in 1843. It was primarily through his efforts that Denmark granted full autonomy and constitutional government to Iceland in 1874.

Sihanouk, Norodom see NORODOM SIHANOUK

Sikhs [seeks] Sikhs are followers of Sikhism, an Indian religion that originated in the Punjab in northwest India. Sikhs are approximately 1.8% of the population of India. Small communities of Sikhs also exist in the United Kingdom, Canada, the United States, Malaysia, and East Africa.

The movement was founded in the Punjab by Guru Nanak (1469–1539), who sought to combine Hindu and Muslim elements in a single religious creed. He taught "the unity of God, brotherhood of man, rejection of caste and the futility of idol worship." He was followed by nine masters, the last of whom was Guru Gobind Singh (1666–1708; guru 1675–1708).

The holiest place for Sikhs is the Golden Temple at AMRITSAR, founded by the fourth guru, Ram Das (guru 1574–81). The fifth guru, Arjun (guru 1581–1606), gave Sikhism its holy book, the Granth Sahib, which contains hymns of Sikh gurus as well as those of Hindu and Muslim saints such as Kabir.

Sikh men are readily identifiable by their turbans. They take a vow not to cut their hair as well as not to smoke or drink alcoholic beverages. When Gobind Singh founded (1699) the martial fraternity Khalsa ("pure"), his followers vowed to keep the five K's: to wear long hair (*kesh*), a comb in the hair (*kangha*), a steel bracelet on the right wrist (*kara*), soldier's shorts (*kachha*), and a sword (*kirpan*). The tradition persists to the present day.

Gobind Singh involved his followers in an unsuccessful martial struggle against Mogul rule. After his assassination, the Sikhs were persecuted by the Muslim Mogul rulers until 1799 when, under Ranjit Singh (1780–1839), they laid claim to a large part of northwest India. After Ranjit's death his Sikh kingdom disintegrated into anarchy. The British moved into the Punjab, and the Sikh Wars followed (1845–46, 1848–49).

The Sikhs were defeated, and the British annexed the Punjab. Sikhism did not recover until the 20th century, when the Sikhs were given control of their holy places (*gurdwaras*). When the Indian subcontinent was partitioned in 1947, the western Punjab became Pakistani territory and the eastern Punjab part of India. The Sikhs were victimized by the ensuing communal rioting, especially in Pakistan's Punjab, and about 2.5 million moved from Pakistan into India.

In 1966 the Indian Punjab was divided into two states—largely Sikh Punjab and predominantly Hindu Haryana. The Punjab was the heart of India's "green revolution," and the Sikhs became one of the most prosperous groups in India. In 1982 a Sikh political party, the Akali Dal, began a campaign for greater Sikh political and religious autonomy.

The Golden Temple in Amritsar, constructed by the guru Ram Das in the 16th century, is Sikhism's preeminent shrine. The temple contains the Granth Sahib, the sacred book of Sikh religion.

Sikkim [sik'-im] Sikkim, located in south central Asia in the southeastern Himalayas, is a former independent nation that is now a state of India. Its area is 7,299 km^2 (2,818 mi^2), and the population is 314,999 (1981). The capital is Gangtok, Sikkim's only town, in the southeastern quarter of the state.

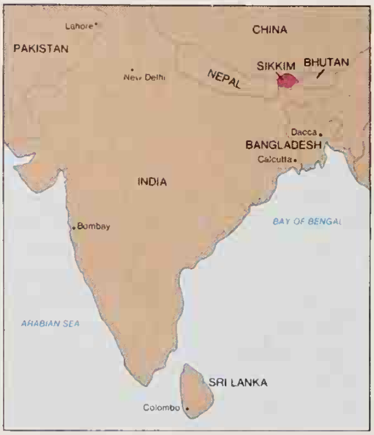
Land and People. Sikkim is a land of mountains, from the foothills of the Himalayas in the extreme south to the high ranges of the north. The Singalila Range, with KANCHENJUNGA near the center, divides Sikkim from Nepal on the west. On the northeast the Donkhya Range marks the boundary with Tibet. Sikkim itself is divided by high ridges and deep valleys; elevations range from more than 6,000 m (19,700 ft) above sea level to 210 m (690 ft) in the southern valleys.

Elevation is the principal determinant of climate and vegetation types. Rainfall is mainly monsoonal and heavy. Gangtok averages more than 3,560 mm (140 in) of precipitation annually. At elevations below 1,520 m (5,000 ft), vegetation is lush and subtropical. Alpine vegetation dominates between 3,650 m (12,000 ft) and the permanently snow-covered elevations above 4,900 m (16,100 ft). Between these two regimes lies a mixed broadleaf-coniferous forest.

More than half of the population of Sikkim is Nepalese; significant numbers of Bhutias and Lepchas constitute most of the remaining half. Tibetan Buddhism is the state religion, but Hinduism is professed by the majority of the population.

Economy. Agriculture dominates Sikkim's economy. Rice is the principal crop, followed by maize, millet, potatoes, and fruits—especially oranges and apples. Agriculture is in general confined to areas below about 2,100 m (6,900 ft). Lack of adequate transport limits timber cutting. Some sheep, goats, and yaks are kept, and handwoven woolen cloth is produced. The Indian government has encouraged the development of mining, small industries, and tourism. Sikkim's hydroelectric power potential is also being developed.

History and Government. The ruling family is of Tibetan origin, and Sikkim was a dependency of Tibet until the British government of India established its protectorate in 1890, following the expulsion of the Tibetans in 1888. A 1950 treaty made Sikkim a protectorate of independent India; the Indian role was extended after India's 1962 border war with China. In 1974, India's position was strengthened after elections in Sikkim diminished the power of the chogyal, or ruler. Even nominal independence ended in 1975 when voters decided to merge their country with India, and Sikkim was incorporated as India's 22d state.



Sikkim, located high in the Himalayas, is bordered by steep mountains on three sides. The location of this formerly independent country gave it strategic importance far greater than its small size would suggest. From 1890 until it became a state of India in 1975, Sikkim served as a buffer between India and China.

Sikorsky, Igor [see-kor'-skee] An innovator in airplane and HELICOPTER design, the Russian-born Igor Ivanovich Sikorsky, b. May 25 (N.S.), 1889, d. Oct. 26, 1972, was educated as an engineer. His early experiments with multiengine planes led to his appointment as chief engineer of an airplane factory, where he produced four-engine bombers for the Russian army during World War I. After the Russian Revolution he emigrated to the United States and established his own company. In the following years, his planes set new records for altitude, speed, and payload; Sikorsky made his most important contributions, however, in the area of helicopter design. His VS-300 became (1939) America's first successful helicopter.

Silas Marner [sy'-luhs mahr'-nur] An early novel by George ELIOT, *Silas Marner* (1861) celebrates the redemptive power of love in a rural setting drawn from Eliot's recollections of her childhood. An embittered weaver, Silas Marner, is won away from his miserliness and isolation by a foundling child whose golden curls come to mean more to him than his lost hoard of gold coins. Ultimately the gold is found, the child's identity established, and a happy ending assured through her loyalty to Silas and marriage to her village sweetheart.

Silent Spring A major impetus to the ecological movement, Rachel CARSON's book *Silent Spring* (1962) criticizes the indiscriminate use of chemical pesticides, fertilizers, and weed killers, citing case histories of damage already done. Fiercely attacked by the chemical industry, the book first appeared as a series of articles in the *New Yorker* magazine. The title refers to the ultimate disappearance of songbirds, whose numbers were diminishing, in Carson's view, because of the effects of the insecticide DDT.

Silenus [sy-lee'-nuhs] In Greek mythology Silenus (often referred to in the plural as the sileni and identified with the SATYRS) was a shaggy, bearded, potbellied old man with a horse's ears who rode an ass and was usually drunk. He was the guardian, tutor, and constant companion of the god DIONYSUS. Silenus had the gift of prophecy and could charm humans and animals with his song.

Silesia [sil-ee'-zhuh] Silesia is a historic region in east central Europe, centered on the middle and upper ODER RIVER basin and bounded on the south by the SUDETEN and western CARPATHIAN Mountains. Most of Silesia lies in southwestern Poland, with smaller sections in north central Czechoslovakia and eastern Germany.

The region was divided historically into three parts. Lower Silesia, to the northwest, includes the valley of the upper Oder, where potatoes, grain, and sugar beets are grown. Austrian Silesia, the southern portion, parallels the Sudeten Mountains northeast into the Polish Upland and is a coal- and iron-mining region. Upper Silesia, to the southeast, is heavily industrialized and has extensive mineral deposits.

Silesia was settled by Slavs in the 6th century AD. From the 10th century, Silesia was ruled by the Polish Piast dynasty, which encouraged German immigration. The region was divided (1163) into Upper and Lower Silesia. In 1335, Silesia passed to Bohemia. Ruled by Hungary (1469–90), it was reacquired by Bohemia, but came under the Habsburgs in 1526. After the War of Austrian Succession (1740–48), most of Silesia was annexed by Prussia. Silesia grew economically under German rule, but Slavic national aspirations ended the region's political unification efforts after World War I. The Treaty of Versailles (1919) initiated a complex series of territorial adjustments, resulting in the loss of most of Upper Silesia to Poland and Austrian Silesia to Poland and Czechoslovakia. Germany reclaimed (1939) Upper Silesia in the occupation of Poland, but it was returned to Poland after World War II with the addition of all of Lower Silesia, except Lusatia, now in Germany. About 3.5 million German-speaking Silesians left the area, which was repopulated by Poles.

silhouette A silhouette is any form defined only by its outline. Such simplified forms have found wide use in posters and other kinds of decorative art. A silhouette portrait, usually a profile, is cut freehand from a piece of paper, ordinarily black, and mounted on a piece of white paper; the result is a shadow portrait of the subject. The art of cutting silhouettes was popular in the late 18th and early 19th centuries, before photography became generally available. The form was named for Étienne de Silhouette (1709–67), comptroller general of France, who proposed to reduce the nobility's wealth to a minimum by taxing them heavily. His name was applied in derision to the currently popular minimal-outline portrait.

silica minerals Silica minerals, a branch of the silicate minerals, are composed of silicon dioxide (SiO_2) and only minor amounts of additional components. At least seven natural polymorphs exist. Quartz, the most abundant, makes up almost 12 percent of the Earth's crust. Cristobalite and tridymite are uncommon; coesite, stishovite, and vitreous silica are rare. Several additional silica polymorphs have been synthesized in the laboratory. Opal, a precious gemstone, is made up of hydrous silicas of several types.

Properties. The silica minerals are hard (6 to 7 on the Mohs scale), resistant to mechanical stress, nonmagnetic, colorless when pure, and nearly insoluble except in hydrofluoric acid. Specific gravity ranges from 2.0 to 2.3 for vitreous silica, opal, tridymite, and cristobalite, to 2.65 for quartz, 2.93 for coesite, and 4.28 for stishovite.

Structure. In stishovite each silicon atom is surrounded by six oxygen atoms in octahedral coordination. All other silica minerals are composed of silicon atoms surrounded by four oxygen atoms in tetrahedral coordination. These tetrahedra are linked into three-dimensional structures, each with a different geometry characteristic of that polymorph. In quartz, cristobalite, and tridymite, tilting of the tetrahedra without structural disruption occurs with temperature increase to give rise to forms with higher symmetry, the so-called high forms.

Occurrence. Silica minerals are major constituents of light-colored igneous rocks such as granite, granodiorite, and quartz monzonite and their volcanic equivalents. Because it is resistant to mechanical and chemical weathering, quartz makes up the bulk of sandstone and siltstone, two of the most common sedimentary rock types. Most metamorphic rocks are also rich in quartz; one type, quartzite, consists mostly of quartz.

silicate minerals Silicates are minerals composed of the elements silicon (Si) and oxygen (O), alone or combined with other elements. Most minerals are silicates; more than 1,000 are known. Together, oxygen and silicon make up about 75 percent by weight of the Earth's crust, and the crust is composed almost entirely of silicates. The surfaces of the Moon and of Mars, and probably the mantle zone within the Earth, are also composed of silicates. The most widely used construction materials—glass, ceramics, brick, concrete, and much building stone—consist entirely or mainly of silicates. Many highly prized gems, such as emerald, aquamarine, tourmaline, and topaz, are silicates.

Atomic Bonds

X-ray crystallography reveals the basic atomic building block of the silicates: the silica tetrahedron (SiO_4), a cluster of atoms composed of a central silicon ion surrounded by four oxygen ions.

A single oxygen ion may bond to two silicon ions, forming clusters or polymers of silica tetrahedra. Two silicon ions with an oxygen in common will form an Si_2O_7 group. Further clustering gives rise to more complex polymers. Because different minerals contain different kinds of clusters, silicates can be classified according to the type of cluster they contain. The common silicates may consist of isolated tetrahedra or of polymers in the form of rings, chains, sheets, or frameworks.

Structural Types

A number of common minerals called orthosilicates contain isolated silica tetrahedra and have SiO_4 as part of their formulas. Examples are the olivines, which include forsterite (Mg_2SiO_4), and the garnet family, of which the most common is almandine [$Fe_3Al_2(SiO_4)_3$]. A few minerals, such as epidote, are made up of double silicate groups, and a few of silicate rings. Among the latter, the best-known are beryl ($Be_3Al_2Si_6O_{18}$) and its gem varieties, which have six-sided rings of six tetrahedra.

Chain silicates, an important and diverse group, include the pyroxenes, containing single chains of composition SiO_3; the amphiboles, with double chains (Si_4O_{11}); and band silicates with multiple chains and complex formulas.

Sheet silicates are widespread, for they include kaolin and other clays (see CLAY MINERALS), MICAS, and TALC. Some, like the clays, occur in microscopic crystals. Those which occur in large crystals, such as the micas, have perfect cleavage, or splitting, parallel to the sheets of silica tetrahedra.

In framework silicates, every oxygen is shared between two tetrahedra, forming three-dimensional networks. The commonest of these, and perhaps the most abundant of all minerals, is quartz (SiO_2). Most other framework silicates, the aluminosilicates, contain some aluminum substituting for silicon, with interstitial ions commonly of calcium, sodium, or potassium. These minerals include the FELDSPARS (the most widespread of all mineral families), the FELDSPATHOIDS (found in silica-poor and alkali-rich rocks), and the ZEOLITES, which occur in pockets in lava.

silicon The element silicon is a dark-colored crystalline semimetal in the same periodic table group (IVA) as carbon and germanium. The name *silicon* is derived from the Latin *silex* or *silicis*, meaning "flint." Its symbol is Si, its atomic number is 14, and its atomic weight is 28.0855. In 1811, Joseph Gay-Lussac and Baron Louis Thenard probably prepared impure amorphous silicon by reacting potassium with silicon tetrafluoride. The credit for discovering the element is usually given to Jons Jacob Berzelius, who also prepared amorphous silicon in 1824 by the same method but purified the product by repeated washings that removed fluorosilicates.

Silicon is present in the Sun and other stars and is a major constituent of the class of meteorites known as aerolites. It is present in the Earth's crust to the extent of 25.7% and is the second most abundant element (after oxygen). The free element silicon is not found in nature, but it occurs either as the oxide SiO_2 (silica), in such forms as sand and quartz, or as silicates in such minerals as granite, asbestos, clay, and mica (see SILICA MINERALS; SILICATE MINERALS). Silicon has a melting point of 1,410° C, a boiling point of 2,355° C, a density of 2.33 g/cm^3 at 25° C, and a valence of 4. It is a relatively inert element but is attacked by halogens and dilute alkali. Silicon is prepared commercially by heating silica and carbon in an electric furnace with carbon electrodes.

Silicon is an important constituent in several structural materials; in the form of sand and clay it is used to make concrete and brick, and sand is also the principal component of glass. Carborundum (silicon carbide) is one of the most widely used abrasives for cutting and grinding metals.

SILICONES, a class of silicon-containing compounds, have useful water-repellant and heat-resistant properties. Even more important are the forms of elemental silicon used in SEMICONDUCTOR devices.

Silicon is essential to plant and animal life; diatoms extract silica from water to build up their cell walls, and silica is present in the ashes of plants and in human skeletons.

silicon-controlled rectifier see SEMICONDUCTOR

silicones Silicones are silicon-containing polymer materials that have found wide use in industry because of their flexibility and resistance to heat, light, and oxidation. They are available as fluids, sealant-adhesives, moldable resins, and rubbers. The first silicone oil was made in the 1870s, the first silicone rubbers in 1943. In the 1950s silicones were developed commercially for the aerospace and electronics industries but rapidly found applications in many fields, especially construction. The desirable properties of silicones are derived from their combination of inorganic and organic chemical groups in a polymer chain. The chain consists of pairs of silicon and oxygen atoms, with two organic groups—usually both methyl (CH_3), but sometimes other groups—attached to each silicon atom.

Silicone fluids are unusually stable when subjected to heat, cold, or oxidizing environments. They are used in heat-resistant oils, greases, and paints; as a component of urethane foams; and as antifoaming compounds. Because of their excellent electrical properties, silicones are used by the electrical industry as liquid dielectrics (insulators).

Silicone rubbers have an unusually wide useful temperature range, –80° to 300° C (–112° to 570° F) and are unaffected by agents that degrade other rubbers. They are compatible with human tissue and have been used in artificial materials implanted in the human body; for example, an artificial heart valve has been developed that uses a silicone rubber ball that seals against a fluorocarbon seal.

Some silicone rubber formulations are called RTV rubbers, for "room-temperature vulcanizing," because when the two components of the rubber are mixed, it vulcanizes (cures) without heat. One-component formulations also exist that vulcanize by means of moisture from air; the silicone sealants and adhesives used in building construction are of this type. Cured silicone rubbers have a nonstick surface; this release property makes silicone rubbers especially effective as mold linings for the molding of polyurethane, epoxy, and other plastics with strong adhesion to other kinds of surfaces.

silicosis Silicosis, one of the oldest known occupational diseases (see DISEASES, OCCUPATIONAL), is caused by the inhalation of small particles of silica, or quartz dust (silicon dioxide). In the lungs the particles are taken up by scavenging microphages, which then die and accumulate near blood vessels. The connective tissue collagen forms around these masses, producing fibrous nodules in the lungs (pulmonary fibrosis). Respiratory problems usually develop 20 to 30 years following initial exposure, sometimes resulting in EMPHYSEMA. Extremely high levels of silica, however, can cause respiratory symptoms much earlier, and in such cases the disease is frequently fatal. Development of concurrent tuberculosis is also often deadly.

Industries whose workers exhibit high rates of occurrence of silicosis include the mining, quarrying, and tunnel-drilling industries and those which use processes involving sandstone abrasives or ground quartz, as in the manufacture of ceramics, paint, paper, plastics, and rubber. No cure has been found for the disease; preventive measures include the use of face masks and, when possible, the substitution of less hazardous materials for silica.

silk Silk is the filament secreted by the silkworm when spinning its cocoon, and the name for the threads, yarns, and fabrics made from the filament. Most commercial silk is produced by the cultivated silkworm, *Bombyx mori,* which feeds exclusively on the leaves of certain varieties of mulberry trees and spins a thin, white filament.

The silkworm constructs its cocoon when it is preparing to enter its chrysalis stage (see BUTTERFLIES AND MOTHS). The cocoon is made from a double filament of silk, wrapped layer by layer around the insect's body and cemented by a gelatinous protein, sericin. If development is allowed to continue normally, in about 2 weeks the chrysalis will break through the cocoon filament and emerge as a moth.

Sericulture

The culture of the *B. mori* silkworm, and the production of raw silk, can take place only where the climate is warm and where the mulberry leaves on which the silkworm feeds are in abundant supply. Over many centuries the *Bombyx* has been bred both for its egg-laying capacity and for the quality and quantity of the silk filament that it spins. The eggs are incubated in the spring and hatch just as the mulberry trees are coming into leaf. The worms are raised on trays kept in a temperature-controlled, antiseptically clean environment. Fully grown in about 5 weeks, the silkworm begins to spin its cocoon, laying filament silk in an endless series of figure eights to form an enclosed shell around itself. When the cocoons are completed, they are heated in special ovens and the worms are destroyed.

After grading, the cocoons are placed in hot water to soften the sericin so that the filament can be removed and wound on reels. Because single filaments are extremely fine, filaments from five to ten cocoons are wound together by drawing them through a porcelain guide and twisting them into a single fiber, glued together by the melted sericin. The process is usually done by machine in a factory called a filature. The reeled yarn is termed *raw silk.*

Raw silk is usually too thin to be used for textile weaving; it is made into a heavier yarn through throwing, a plying process. The fiber is first twisted, then plied with another yarn and twisted again.

More than any other natural fiber, silk has a remarkable affinity for color. Dyes are applied either to the unwoven skein or to the woven fabric after the sericin is boiled off, or degummed. Silk yarn is woven into a wide range of fabrics, and it is often used in combination with other fibers to produce fabrics of great beauty, durability, and warmth.

Properties of Silk

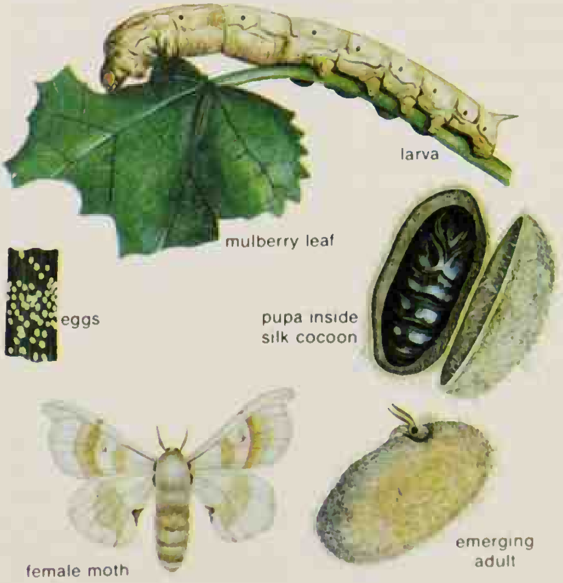
Despite its delicate look and feel, silk is the strongest of all natural fibers. Woven into cloth, silk is lightweight but retains warmth, and it is valued as an insulating liner in gloves and footwear. Nevertheless, it is the coolest of hot-weather fabrics, and it can absorb up to 30 percent of its weight in moisture without feeling wet. The fiber is remarkably resistant to heat and will burn only as long as a flame is applied to it. Its low conductivity makes it excellent for electric-wire insulation. Before nylon, silk was the only fiber strong and light enough to be used for parachutes, sheer hosiery, and surgical sutures.

History

Silk culture originated in China, perhaps as early as the 3d millennium BC. The wearing of silk apparel was for centuries the exclusive prerogative of the Chinese nobility, and knowledge of sericulture was kept secret.

Europe. Although samples of Chinese silk occasionally reached the West, the fabric became an item of trade only when the Han dynasty (206 BC–AD 220) finally authorized its exportation. Silk fabrics were carried over caravan routes extending from central China through India to Baghdad, Damascus, and other trade centers in the Middle East. From there, and particularly from Persia, silk was reexported to Mediterranean Europe, where the demand for it soon exceeded the supply. A domestic silk dyeing and weaving industry developed, but no non-Chinese supply of raw silk could be established until the fiber source was revealed.

In the life cycle of silkworms, eggs are laid on a mulberry plant, upon which the hatched larvae feed. Silk fiber is derived from the cocoons that the larvae spin. Adult moths emerge from the cocoons, if left untouched, and begin the cycle anew.



In AD 552 two Persian monks who had lived in China brought the secret with them to Constantinople in the form of silkworm eggs and mulberry seeds concealed inside their hollow bamboo canes. Under the emperor Justinian I (AD 527–65), Constantinople became the Occidental center of raw silk production, and its silk fabrics were used throughout Europe for sumptuous garments and ecclesiastical vestments.

The Greeks, the Syrians, and the Arabs learned the silk art in Constantinople, and when the Moors invaded Europe they introduced sericulture into Spain and Sicily. Italy by the 12th century had become the silk capital of the West, and the textiles produced there during the Renaissance are still regarded as among the most beautiful ever made. The French city of Lyon also became an important producer of silk fabrics and, by the end of the 17th century, France established a thriving industry by subsidizing the planting of mulberry orchards. England, too, established a silk-weaving industry, whose artisans were originally French and Flemish émigrés.

Japan and India. The secret of sericulture was smuggled into Japan in the 3d century AD, carried—according to legend—by four Chinese concubines who also instructed the Japanese nobility in the weaving of silk. By the 7th century, Japan had developed the new craft into an industry of major national importance and had begun its attempts to improve silkworm breeds and culture.

India had produced fabrics from wild silkworms as early as 1400 BC and had obtained knowledge of the Chinese process by 400 BC, although the cultivated *B. mori* has never flourished in India. Consequently, silk culture remains even today primarily a cottage industry.

The Americas. Many attempts have been made to introduce silk culture into the Americas and, particularly, into the United States. Although the first U.S. silk-weaving mill was built in 1810, and, in the 1830s, Paterson, N.J., called itself "The Silk City of the World," efforts to develop a domestic silk culture failed, in part because of a lack of suitable mulberry trees.

World Production of Raw Silk

Sericulture on a large scale is confined almost entirely to Asia. China is by far the largest producer of raw silk, and—although precise figures are hard to come by—it is estimated to have produced over 30,000 metric tons annually in the mid-1980s. Japan's production is about half that of China's. The USSR is the third-largest producer, with about 4,000 metric tons. South Korea and India are also major producers, although much of India's silk is of an inferior, or ungraded, variety. Italy's once sizable silk industry has shrunk dramatically. In the Americas, only Brazil has managed to establish a significant silk industry.

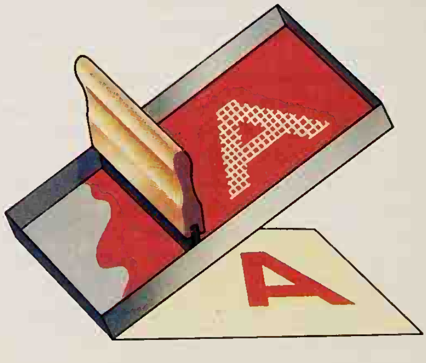
Silk Road The Silk Road, an ancient trade route that linked China with the West, existed as early as the 3d century BC. Commencing in what is today western Iran, it passed south of the Caspian Sea and then divided into a northern branch through Samarkand and a southern route that followed the Oxus (now Amu Darya) River. After circling the borders of the Takli Makan Desert, the two routes rejoined at DUNHUANG in northwest China. The Silk Road served as a commercial and cultural bridge between East and West. Dominated sporadically by nomadic tribes and the Chinese, it fell under Islamic Turkish rule in the 10th century and then under Mongol domination in the 13th century. After the opening (15th century) of a sea passage between Europe and India, its importance declined.

silk-screen printing Silk-screen printing is a printing process in which ink is transferred to a receptive surface through a stencil supported on a fine fabric mesh of silk, synthetic fibers, or metal threads stretched tightly over a frame. The pores of the mesh are blocked by the stencil in the background, or nonimage, areas, and left open in the areas to be printed. Ink is spread over the screen and pushed through the open mesh areas with a rubber- or plastic-bladed squeegee to produce a print.

Stencils may be hand-cut or produced photographically. Photostencils are produced on either a special adhesive-backed film or by coating the screen itself with a light-sensitive emulsion. After exposure through a film positive, photostencils are developed in water; image areas remain soluble and are washed away during development. Machines for screen process are unlike those for any other process; the inside of the screen frame itself acts as the ink storage duct. Ink is passed across and through the screen by the action of the squeegee. Hand screen-printing tables are used for some work, such as short runs and very thick or thin materials, but much screen work is now printed on fully automated sheet-fed presses, both flatbed and cylinder, operating at 4,000 to 6,000 impressions per hour.

No other printing process is as versatile as screen printing. It can print on almost any kind of surface—wood, metal, glass, foil, plastic, paper, or fabric—and is used for the production of artworks, posters, transfers, and showcards; for electronic circuits; for printing on packaging containers; and for industrial applications such as instrument panels.

Silk-screen printing is used for printing designs or letters on a variety of surfaces, including fabric, wood, and paper. The process involves pressing ink through the open pores of a stencil supported on a framed fabric screen.



silkworm see SILK

silky terrier The silky terrier, formerly the Sydney silky, is a toy breed of dog developed in Australia about 1900 by crossing Australian terriers with Yorkshire terriers. The breed was officially recognized by the American Kennel Club in 1959. The low-set silky terriers have small prick ears and resemble the Australian and Yorkshire terriers in overall appearance. They are 23 to 25 cm (9 to 10 in) at the shoulder and weigh 18 to 22 kg (8 to 10 lb). The blue and tan coat is flat, fine, glossy, and silky. On the body the coat should be 13 to 15 cm (5 to 6 in) in length, and it is parted down the spine. The hair is profuse on the head, forming a topknot.

sill A sill is a tabular body of IGNEOUS ROCK that is intruded into bedded sedimentary or volcanic rocks parallel to bedding planes. Large sills, such as the Palisades Sill along the Hudson River in New York and New Jersey, consist of coarse-grained jointed rock such as basalt that shows chemical differentiation from the bottom to the top of the intrusion.

Sillanpää, Frans Eemil [sil'-lahn-pa] A Finnish novelist and short-story writer who won the Nobel Prize for literature in 1939, Frans Eemil Sillanpää, b. Sept. 16, 1888, d. June 3, 1964, is most widely known for his novels *Meek Heritage* (1919; Eng. trans., 1938), about Finland's civil war in 1918; *Fallen Asleep While Young* (1931; Eng. trans., 1933); and *People in the Summer Night* (1934; Eng. trans., 1966). Although inclined to stress biological determinism in his works, Sillanpää also shows psychological understanding in his descriptions of people who are destroyed as much by their inner weaknesses as by events.

Silliman, Benjamin [sil'-uh-muhn] The American chemist Benjamin Silliman, b. Trumbull, Conn., Aug. 8, 1779, d. Nov. 24, 1864, was an influential professor, lecturer, and textbook writer who founded the *American Journal of Science and Arts* in 1818 and was its first editor. He graduated (1796) from Yale College and later became (1802–53) professor of chemistry and natural history there. Through Silliman's energies, Yale became a leading institution for chemistry, geology, and mineralogy. He was also instrumental in the development of a medical school at the college.

Sillitoe, Alan [sil'-uh-toh] An English writer whose fiction reflects his working-class upbringing, Alan Sillitoe, b. Mar. 4, 1928, was among the leading literary talents to emerge during the 1950s. His novel *Saturday Night and Sunday Morning* (1958; film, 1960) and the short-story collection *The Loneliness of the Long-Distance Runner* (1959; film, 1961) are powerful portrayals of alienated working-class youth, and both became important British films. Sillitoe's later works have included collections of poetry, travel books, several novels for children, a memoir (*Raw Material*, 1972), and a series of novels (for example, *Out of the Whirlwind*, 1988) that develops early themes.

Sills, Beverly Beverly Sills, originally named Belle Silverman, b. Brooklyn, N.Y., May 25, 1929, the popular coloratura soprano, started her career at the age of 3. She began vocal studies with Estelle Liebling at 7, and by age 12 was a veteran of radio and films. She made her professional operetta debut (Gilbert and Sullivan) in 1945, and her opera debut in 1948 as Frasquita in Bizet's *Carmen* with the Philadelphia Civic Opera.

In 1953, Sills joined the New York City Opera, creating in 1956 the title role in Douglas Moore's *Ballad of Baby Doe*. Ten years later, at Central City, Colo., she achieved international fame as Cleopatra in Handel's *Julius Caesar*. Subsequently, she was a guest at major European and American opera companies, singing the heroine roles in more than 50 operas, including those of Bellini, Donizetti, Massenet, Mozart, Rossini, and Verdi. She has also appeared in operas on television, in specials with Danny Kaye and Carol Burnett, and in her own weekly discussion series, "Lifestyles." She retired from the stage in 1980 and served (1979–89) as director of the New York City Opera.

Beverly Sills, an American opera soprano, first achieved international recognition in 1966 with her performance as Cleopatra in Handel's opera Julius Caesar. *Sills began her career at the age of 3 and has appeared in more than 50 operas. From 1979 to 1989 she was director of the New York City Opera.*

Siloe, Diego de [see-loh-ay'] Diego de Siloe, b. *c.*1495, d. 1563, one of the greatest sculptors and architects of the early Renaissance in Spain, was the son of Gil de Siloe, a notable sculptor of the late Gothic period. His early training took place in Italy. On returning to his native city of Burgos, he introduced the classical grandeur and corporeality of the style of Donato Bramante, as seen in his work for the Cathedral of Burgos (1519–26). In

1528 he went to Granada, where his design for the cathedral (begun 1528), based on the Church of the Holy Sepulchre (early 4th century) in Jerusalem, established him as one of the geniuses of the age.

Silone, Ignazio [see-loh'-nay] The Italian writer Ignazio Silone, pseudonym of Secondo Tranquilli, b. May 1, 1900, d. Aug. 22, 1978, gained fame as an outspoken critic of Mussolini's regime. His anti-Fascist activities forced him to flee to Switzerland in 1930. Silone had participated in the founding of the Italian Communist party, but he left it in 1931. The story of his disaffection with Communism may be read in *The God That Failed*, edited by Richard Crossman (1949).

Silone's first novel, *Fontamara* (1933; Eng. trans., 1934), attracted worldwide attention because of its description of the Italian peasant who bore not only the burden of a semifeudal way of life but also the yoke of modern fascism. *Bread and Wine* (1936; Eng. trans., 1937) is the story of an underground political activist disguised as a priest. Many consider Silone's best work to be the play *The Story of a Humble Christian* (1968; Eng. trans., 1970), which expresses his populist conception of Catholicism.

Silurian Period see EARTH, GEOLOGICAL HISTORY OF; GEOLOGIC TIME

silver Silver, atomic number 47, is a coinage metal with properties closely resembling copper and gold, with which it is grouped (1B) in the PERIODIC TABLE. Its symbol, Ag, is derived from the Latin *argentum*, meaning "white and shining," an apt description of this element.

History. The earliest uses of silver are lost in ancient times. Because silver is easily reduced to pure metal from its ores by relatively low heat, and because it is occasionally found free in nature, it probably became the third metal (after gold and copper) that ancient civilizations learned to use. It was well known earlier than 4000 BC.

Occurrence. Silver is the 68th most abundant element in the Earth's crust and 65th in cosmic abundance. Large amounts of the metal have been mined in both North and South America, which together produce over half the world total. Its most important ores are sulfides, of which argentite (silver sulfide, Ag_2S) is the most common. Silver often occurs as a minor constituent in the ores of copper, lead, and zinc and is found in minute quantities in seawater. Historically, the important mines have been those discovered by the Spaniards in Central and South America and Mexico during the 16th century, and the COMSTOCK LODE discovered in Nevada in 1859.

Physical Properties. The atomic weight of silver is 107.868, and natural silver consists of two stable isotopes: silver-107 (51.82%) and silver-109 (48.18%). The melting point of the metal is 960.8° C, and it boils at 2,210° C.

Next to gold, silver is the most malleable and ductile metal known. It is harder than gold but softer than copper. This softness limits its use, even for coinage, unless it is alloyed with about 10% copper. When alloyed with 7.5% copper, it is known as sterling silver. It is the best conductor of heat and electricity of any of the metals.

Chemical Properties. Although silver dissolves readily in nitric acid, it resists most other acids. It will also dissolve in solutions of sodium or potassium cyanide, but not in sodium or potassium hydroxide solutions or fused salts. It does not normally oxidize in air, but it does react with sulfides and with the hydrogen sulfide (H_2S) found in the atmosphere of many industrial cities, forming a black film of silver sulfide (Ag_2S).

Extraction and Refining. Silver occurs in the ores of several metals; COPPER refining in electrochemical cells is the source of a large quantity. During electrolysis, impurities settle to the bottom of the cell as an electrode mud, or sludge. Silver, gold, and other scarce elements are recovered from this sludge.

For ores in which silver or gold or both are the only valuable minerals, the cyanide process is generally the method of choice. It can also be used to reclaim silver from zinc ores after the volatile zinc has been distilled from them. In this process a dilute sodium cyanide solution is used to dissolve the silver in the presence of air. The silver cyanide complex, after removal from the unreacted ore, is treated with zinc dust to recover elemental silver. The cyanide process appeared about 1859 and was responsible for the recovery of the silver of the famous Comstock Lode.

By 1910 the froth process of concentrating silver ores became common and today accounts for about 75% of all silver recovered. Here the ore is ground to a powder, placed in large vats containing water suspensions of frothing agents, and thoroughly agitated by jets of air. Depending on the agent used, either the silver-bearing ore or the gangue adheres to the bubbles of the froth, is skimmed off, and is washed. The final refining is electrolytic.

Uses. Historically, the principal use of silver has been for coinage, but its unique properties and the demand for more sophisticated manufacturing methods and product uses have relegated coinage to a minor application. By 1986, 44% of all silver used was for photographic processes, 25% for electrical and electronic products, 10% for jewelry and silverplate and sterling ware, and only 6% for coinage.

Silver's exceedingly high electrical conductance and resistance to oxidation make it valuable in critical electrical contacts, switches, printed circuits, solders, long-lasting batteries, and many forms of electrical and electronic equipment. It is used in bearing alloys for airplanes and diesel engines and recently in some automobiles as well, for the production of mirrors and photochromic lenses, in colloidal form as a catalyst in the manufacture of certain alcohols, as an alloy with cesium in photocells, and in silver-copper alloys for welding.

Colloidal silver is used as an antiseptic, germicide, astringent, and caustic and for water sterilization. Prolonged ingestion of even small quantities may cause silver poisoning, called argyria. Symptoms include a blue coloration of lips and gums as silver is deposited there.

The photographic industry, the largest single user of silver, depends on the chemical reactions of the element. Photographic film is composed of an acetate film on which has been spread a thin gelatin layer, the emulsion, containing a silver halide (as well as organic and inorganic sensitizing compounds). Light causes an oxidation reaction such as light + $Br^- \rightarrow Br^0 + e^-$. This electron reacts with the silver ion, $Ag^+ + e^- \rightarrow Ag^0$, forming an elemental silver atom that is suspended in the gelatin emulsion; the more light striking any portion of the film, the more elemental silver atoms are suspended. The silver and bromide ions that are photooxidized represent too small a portion of those present in the emulsion to be useful. The film is bathed in a developer, which is designed to continue the oxidation in those crystals in which it has already been started by light energy but which has no effect on crystals as yet unaffected. The film is still light-sensitive, and further exposure would cause all silver to be converted to the elemental state; therefore, it is fixed in a bath containing sodium thiosulfate. This chemical, $Na_2S_2O_3$, coordinates with the silver to form ions that can be washed away, leaving a negative image from which the positive print can be made. While the above description refers to black-and-white photography, color PHOTOGRAPHY is much the same.

silverfish see BRISTLETAIL

silverpoint see DRAWING

silversides Silversides, family Atherinidae, are about 156 species of mostly small, usually slender fishes. They range from about 5 to 60 cm (2 in to 2 ft) in length, have two dorsal fins, and lack a lateral line. They typically have a broad, silvery band along each side. Often called sand smelts, most species occur in large schools in shallow, temperate or tropical marine waters around the world. A number of the marine species enter brackish waters, certain species are found only in fresh water, and still others inhabit both fresh and brackish waters. The most famous species is the GRUNION.

Sima Qian (Ssu-ma Ch'ien) [sih-mah kee-ahn] Sima Qian, *c.*145–*c.*87 BC, was the official court historian of Emperor Wudi of the HAN dynasty in ancient China. He wrote the *Shi Ji* (Records of the Historian), the first general history of China from its earliest times. The work records 2,000 years of history and consists of 130 chapters, 100 of which are biographical. It is written in a lively but terse style and continues to influence the historical writing and literary tastes of China, Japan, and Korea.

Simcoe, John Graves [sim'-koh] John Graves Simcoe, b. Feb. 25, 1752, d. Oct. 26, 1806, was a British army officer and colonial administrator. He entered the army in 1771 and served throughout the American Revolution, commanding (1777–81) a Loyalist corps, the Queen's Rangers. In 1791 he was appointed the first lieutenant governor of Upper Canada (now Ontario). Although his aristocratic pretensions were unsuited to a frontier colony, he contributed greatly to the province's development, fostering agricultural advancement, opening new roads, and encouraging immigration from the United States. In 1796 he took command of British forces on Hispaniola, returning to England 5 years later to defend Plymouth when a French invasion was threatened.

Simenon, Georges [seem-nohn'] The Belgian-born French writer Georges Simenon, b. Feb. 13, 1903, d. Sept. 4, 1989, is among the world's most widely read authors. His works include both detective novels featuring police inspector Jules Maigret (the first was *The Strange Case of Peter the Lett*, 1931; Eng. trans., 1933) and novels of psychological analysis, for example, *The Man Who Watched the Trains Go By* (1938; Eng. trans., 1942), *Act of Passion* (1947; Eng. trans., 1952), and *The Little Saint* (1965; Eng. trans., 1966). Simenon's many books—he wrote more than 200 novels under his own name and many others under various pseudonyms—evoke atmosphere with great economy and plumb the inner, often pathological lives of his characters. Among his books of nonfiction are several autobiographical works, including *Intimate Memoirs* (1981; Eng. trans., 1984).

Simeon Stylites, Saint [sim'-ee-uhn sty-ly'-teez] Saint Simeon Stylites, *c.*390–*c.*495, a Syrian Christian ascetic, was the first of the so-called pillar ascetics in early Christianity. After being dismissed from a Syrian monastery for excessive austerity, he became a hermit on Mount Telanissae. He eventually moved to a platform at the top of a pillar (*stylos*), where he remained until his death. He was widely imitated, and his advice was sought by thousands of pilgrims. Feast day: Sept. 1 (Eastern); Jan. 5 (Western).

Simeon I, Tsar of Bulgaria Simeon I (also Symeon), b. *c.*863, d. May 27, 927, first tsar of Bulgaria, expanded his domain by conquest, introduced Greek culture to Bulgaria, and ruled during the period when Church Slavonic literature flourished. He was educated as a monk at Constantinople and succeeded his brother Vladimir (r. 889–93). In a series of campaigns against the Byzantine Empire (894–97, 913–14, 919–24), Simeon conquered most of Serbia and required Constantinople to pay him tribute. He assumed the title tsar (emperor) of the Romans and Bulgars in 925; the title was recognized by the pope the following year.

simile see FIGURES OF SPEECH

Simmel, Georg [zim'-ul] The German philosopher Georg Simmel, b. Mar. 1, 1858, d. Sept. 28, 1918, was one of the founding fathers of modern sociology. After obtaining his doctorate from the University of Berlin in 1881, Simmel as a university lecturer introduced the first courses in sociology ever given in Germany. Not until 1914, however, did he obtain a chair in philosophy, at the University of Strasbourg.

Simmel's interest in the development of human personality was the link between his work in philosophy and sociology. He was among the first to recognize, designate, and analyze the impact of social differentiation, social-group expansion, economic structure, and other developmental and environmental factors on the realization of individual human potential. His most important contribution was probably his conception of sociology as an independent discipline whose province was the whole of social reality.

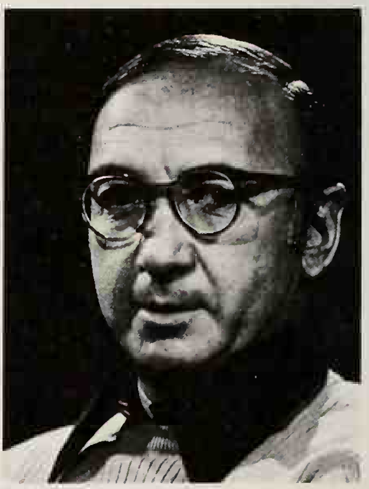
Simon, Saint Saint Simon the Less, one of the 12 apostles, appears only in the biblical lists of Jesus' disciples. Called the Zealot by Luke and called the Cananaean (Aramaic for "zealot") by Matthew and Mark, he may have originally belonged to the Zealots, an extremist group opposed to Roman rule in Palestine. Feast day: May 10 (Eastern); Oct. 28 (Western; with Saint Jude).

Simon, Claude [see-mohn'] Winner of the 1985 Nobel Prize for literature, French writer Claude Simon, b. Oct. 10, 1913, is a major proponent of the "new novel." Although he disregards chronological development, Simon does employ recognizable events—the Spanish Civil War in *La Corde raide* (The Taut Rope, 1947); France's 1940 capitulation in *The Flanders Road* (1960; Eng. trans., 1961)—to establish the backgrounds of his novels. An exception is *The World about Us* (1975; Eng. trans., 1984), an almost plotless novel that focuses obsessively, and as if with a magnifying glass, on things in themselves.

Simon, Herbert A. Herbert Alexander Simon, b. Milwaukee, Wis., June 15, 1916, is an American social scientist and computer theorist who made pioneering contributions in the fields of mathematical economics, organization theory, cognitive psychology, and ARTIFICIAL INTELLIGENCE. His influential book *Administrative Behavior* (1947; 3d ed. 1976) set forth his theory of corporate decision-making, known as "behaviorism." His later research on the psychology of problem solving showed how cognitive processes can be explained in information-processing terms and modeled with computer programs. Simon won the 1978 Nobel Prize for economics for his "research into the decision-making process within economic organizations."

Simon, Jules François [see-mohn'] Jules Simon, b. Dec. 31, 1814, d. June 8, 1896, a French republican, was the key figure in the governmental crisis of *seize mai* (May 16, 1877). A philosopher and academician, Simon was elected to the National Assembly (1848) and the Corps Législatif (1863) and became minister of education, religion, and fine arts in 1871. As premier (1876–77), he was more responsive to the republican cabinet than to President Marie Edmé Patrice de MACMAHON, a monarchist. MacMahon forced him out of office on May 16, 1877, and the resulting constitutional crisis challenged MacMahon's use of his presidential power. A republican victory in the next election finally established the primacy of the parliament over the president.

Simon, Neil The contemporary American theater's most commercially successful playwright, Marvin Neil Simon, b. the Bronx, N.Y., July 4, 1927, writes well-constructed situation comedies on themes reflecting such typically middle-class concerns as marriage, sex, loneliness, and aging. Initially a television writer, Simon began his Broadway career in the late 1950s. In addition to *Come Blow Your Horn* (1961; film, 1963) and *Barefoot in the Park* (1963; film, 1967), his plays include *The Odd Couple* (1965; film, 1968), later adapted into a long-running television series; *Plaza Suite* (1968; film, 1971); *The Sunshine Boys* (1972; film, 1975); *Chapter Two* (1977; film, 1979); and the musical *They're Playing Our Song* (1979). The scriptwriter for many of the movies made from his own plays, Simon has also written such original film scripts as *Murder by Death* (1976) and *The Goodbye Girl* (1977). Later plays include the semiautobiographical trilogy *Brighton Beach Memoirs* (1983; film, 1986), *Biloxi Blues* (1985, Tony Award; film, 1988), *Broadway Bound* (1987), and *Lost in Yonkers* (1991, Tony Award).



Neil Simon is one of America's most popular writers of comedies. In such plays as Come Blow Your Horn *(1961),* Barefoot in the Park *(1963), and* The Odd Couple *(1965), Simon has chronicled the triumphs and heartaches of contemporary middle-class life in the United States.*

Simon and Garfunkel [gar'-funk-ul] The vocal and instrumental duo Simon and Garfunkel, Paul Frederick Simon, b. Newark, N.J., Oct. 13, 1941, and Art (Arthur) Garfunkel, b. Forest Hills, N.Y., Nov. 5, 1941, grew up together in Forest Hills. Their early material—most of it written by Simon—was close to folk music in feeling and scoring, although the duo's most successful songs were recorded with a rock-band backing. The 1966 album *Sounds of Silence* was a smash hit. The 1967 song "Mrs. Robinson," written for a popular film, *The Graduate*, propelled the duo to worldwide fame; their 1970 album, *Bridge over Troubled Water*, achieved sales of more than 8 million. The pair separated in 1970. On his own, Simon experimented with African pop idioms in albums such as *Graceland* (1985), and Garfunkel has acted in films and made some albums. They performed together in *Concert in Central Park* (1982).

Simon Magus [sy'-muhn may'-guhs] A Samarian sorcerer mentioned in the New Testament (Acts 8:9–24), Simon Magus was condemned by the apostle Peter for seeking spiritual power through the payment of money (hence the term simony). Later tradition identifies Simon Magus as the founder of a gnostic sect that was active in the 2d and 3d centuries; this sect regarded their founder (one Simon from Gitta in Samaria, according to Justin Martyr) as a god. Most scholars now believe that Simon of Gitta was a different person, who probably lived in the 2d century.

Simonov, Konstantin Kirill Mikhailovich [see'-muh-nuhf] Popular outside the Soviet Union for his novel *Days and Nights* (1944; Eng. trans., 1945), Konstantin Simonov, b. Nov. 28 (N.S), 1915, d. Aug. 28, 1979, was admired in his own country as a poet, playwright, journalist, and proponent of socialist realism. A prominent party member and editor, he was at least partly responsible for the publication of a wider range of political views until, in 1957, he was labeled revisionist and removed the next year from his editorial post at *Novy Mir* (New World). He won the Stalin Prize many times.

simony [sy'-muh-nee] The term *simony*, in Christian canon law, refers to the sale or purchase of a spiritual service, benefit, or office. The term derives from Simon Magus, who tried to buy the gifts of the Holy Spirit from the apostle Peter (Acts 8:9–24). Simony, in its most common form of buying church offices, was first condemned by the Council of Chalcedon (451). In the Middle Ages, however, it was a widespread practice. Partly curbed by the 11th-century reforms of Pope Gregory VII, traffic in ecclesiastical offices remained a problem up to the time of the Reformation (16th century). The sale of indulgences was also a form of simony.

simple machines All complex machinery is an example of, or a combination of, a few basic types: the lever, the inclined plane, and the pulley. These three types are the three primary simple machines; secondary simple machines include the wedge and the screw, which are variations of the inclined plane; and the wheel-and-axle combination, a variation of the lever. Simple machines were known and used in ancient times.

Force v. Distance. Simple machines magnify force. In return, the force must move through a greater distance to accomplish the same work as the greater direct force. Occasionally, simple machines are used in reverse; for example, to magnify the distance through which an object moves. In this case, a greater force must be applied.

Mechanical Advantage and Efficiency. The mechanical advantage of a machine is the ratio of output force to input force. For example, machines that magnify force threefold have a mechanical advantage of 3. If no energy is lost to friction, this ratio is the same as the ratio of the input distance moved to the output distance moved. The ratio of distances moved always equals the ideal mechanical advantage. If energy is lost, generally because of friction, the actual mechanical advantage is less than the ideal value.

Work is calculated as the product of force times distance moved. The ratio of output work to input work is called the efficiency of the machine and is always less than 1. The figure for output force is smaller than that for ideal mechanical advantage because of slight losses. This prevents a perpetual motion machine from ever being built.

The Lever. The simplest lever is a crowbar, a long pole of wood or metal. One end of a crowbar is pried under the object to be lifted, and a solid block is slid under the bar, close to that end. The point around which the bar turns, in this case the block, is called a fulcrum. Pushing down with a small force on the far end of the lever causes the bar to rotate on the fulcrum, exerting a much greater force at the short end. The distance that each end moves is proportional to the length of the bar from that end to the fulcrum.

The Inclined Plane. The inclined plane is a simple machine that allows a heavy object to be raised with a small force by exerting that force for a long distance along a ramp or slope. The mechanical advantage is equal to the length of slope divided by the vertical height raised. Inclined planes are built into a variety of tools. A screw, for example, can be thought of as a circular inclined plane. A wedge is a double inclined plane, exerting a large sideways force through a small distance, in return for a smaller driving force exerted over a larger distance.

The Pulley. A rope turning on a wheel is the basic unit of the pulley. All a single wheel does, however, is to change the direction of the rope and its pull. There is no mechanical advantage, for instance, in pulling down a rope that passes over a pulley wheel on the ceiling and then pulls up on a load. However, if the pulley wheel can be arranged so that two vertical sections of the rope support the load, the required input force is cut in half. This situation can be arranged by tying one end of the rope to the ceiling, feeding it through a pulley wheel attached to the load, and then bringing the free end back up. If a person were on a balcony over the load, he or she could raise it in this manner by pulling up with a force one-half the weight of the load. The ideal mechanical advantage in this case is 2.

The Wheel and Axle. The wheel and axle can be thought of as a circular lever. If two wheels with different radii are mounted on the same axle, a small force exerted along the rim of the large wheel produces a large force at the rim of the small wheel. The tangential force at each rim operates on a lever arm with a length equal to the radius of the wheel. The tangential force can be exerted by a rope wound around the rim. The wheel and axle is also the basis for doorknob operation or a screwdriver. If the two wheels are mounted on different axles, the wheel-and-axle principle still holds if one wheel drives the other with teeth on the rims, or with belts or chains. Such a machine is called a gear train.

See also: STATICS.

Simplon Pass [sim'-plahn] The Simplon Pass through the Alps of southern Switzerland lies on the western slope of Monte Leone, about 8 km (5 mi) northwest of the Italian border. Approximately 40 km (25 mi) long, it has a maximum elevation of 2,005 m (6,578 ft). The pass has been important since the mid-13th century. Napoleon's engineers built (1800–1805) a road through the pass in order to facilitate the French control of northern Italy. The 20-km-long (12.5-mi) Simplon Tunnel, cut through Monte Leone and opened in 1906, is one of the longest railroad tunnels in the world.

Simpson, Sir George Sir George Simpson, b. *c.*1787, d. Sept. 7, 1860, a British administrator and world traveler, has been called one of the "makers of Canada." Born in Scotland, he worked in London as an accountant before joining the HUDSON'S BAY COMPANY in 1820; he played an important part in bringing about the company's union with the NORTH WEST COMPANY. Simpson became (1821) governor of the Hudson Bay's northern department, and 5 years later he was named governor in chief of the company's territory of Rupert's Land, a post he held until his retirement in 1859. He was knighted in 1841.

Simpson's administration was marked by firmness, vigor, and attention to detail. He encouraged exploration and traveled by canoe over vast areas of North America, usually accompanied by a Scottish piper.

Simpson, George Gaylord George Gaylord Simpson, b. Chicago, June 16, 1902, d. Oct. 6, 1984, an American paleontologist and zoologist, contributed greatly to an understanding of evolutionary theory. After obtaining his doctorate in geology from Yale University in 1926, Simpson joined the staff of the American Museum of Natural History in New York City. He then undertook expeditions to the western and southeastern United States and to southern South America in pursuit of fossil finds. Pioneering in the use of statistical methods in paleontology, Simpson analyzed fossil finds, particularly those of mammals, and determined the distribution changes, migration patterns, and probable evolutionary histories of mammalian groups in past geological times. He later joined the staff of Columbia University and then of the Harvard Museum for Comparative Zoology.

Simpson, O. J. The football star Orenthal James Simpson, b. San Francisco, July 9, 1947, first gained fame as a running back (1967–68) for the University of Southern California, where he won the 1968 Heisman Trophy. During his National Football League (NFL) career (Buffalo Bills, 1969–78; San Francisco 49ers, 1978–79), Simpson, nicknamed "The Juice," continued his smooth, deceptive running style and produced NFL single-season records for most yards rushing (2,003 in 1973; broken in 1984 by Eric Dickerson) and most touchdowns scored (23 in 1975). He retired with an 11,236-yd rushing total. Simpson gained over 200 yd in a game more times (6) than anyone else. He was elected to the Pro Football Hall of Fame in 1985.

O.J. Simpson established what was then an NFL single-season rushing record in 1973 when he gained 2,003 yd. On retiring in 1979 to pursue a career in film and television, Simpson ranked second behind Jimmy Brown in career rushing yardage for the National Football League.

Simpson, Thomas Thomas Simpson, b. July 2, 1808, d. June 14, 1840, was a British Arctic explorer who discovered Victoria Island, Canada. He joined the Hudson's Bay Company in 1829 and took part in expeditions (1836–40) that charted much of the Arctic Ocean coastline.

Simpson Desert The Simpson (formerly Arunta) Desert is a largely uninhabited region of parallel sand dunes in central Australia. Covering 77,000 km^2 (29,730 mi^2), the desert lies mainly in the southeastern Northern Territory, but it also reaches into Queensland and South Australia. The area was mapped by an aerial survey in 1929 and crossed on foot in 1973.

Sims, William Sowden William Sowden Sims, b. Port Hope, Upper Canada (now Ontario), Oct. 15, 1858, d. Sept. 25, 1936, was a U.S. admiral and a longtime advocate of a modernized, efficient navy. He graduated from the

U.S. Naval Academy in 1880. In 1902, President Theodore Roosevelt, impressed by a report that Sims had made on the condition of the navy, had him brought to Washington. Sims was president (1917, 1919–22) of the Naval War College. During World War I he commanded U.S. naval forces in Europe, and he continued his criticisms of the navy after the war. He wrote, with Burton J. Hendrick, the Pulitzer Prize–winning book *The Victory at Sea* (1920).

sin Sin is a theological term for evil behavior, individual or corporate. It is to be distinguished from crime, a legal term applied to a breach of the rules that society imposes on its members, and from vice, a moral term applied to a practice or habit that is injurious to a person's moral nature. Sin specifically refers to conduct that involves a wrong attitude toward God and results in alienation from him.

All the major religions have a concept of sin, although they differ widely in their interpretation of its meaning. Hinduism, for example, in the doctrine of KARMA, presents a system by which human action works itself out in retribution or reward by rebirth in another existence. Good action loosens the grip of the world of the senses; bad action degrades and binds its victim more fully to the cycle of karma and the TRANSMIGRATION OF SOULS. Final deliverance from the round of rebirths comes only when the soul ceases to desire or to act and is absorbed into the divine source from which it came.

Judaism, Islam, and Christianity teach that sin is an offense against a personal God. In the Old Testament, or Hebrew Bible, sin is seen as transgression against the law of God. The first sin was committed by Adam and Eve, and the effects of that sin have passed on to their descendants. In Christian theology this ORIGINAL SIN is understood to have resulted in a change in the souls of individuals so that they are born as sinners and the tendency to sin is rooted in their nature.

Islamic teaching on sin derives from the ethical and religious injunctions of the Koran and traditions (hadith). It has much in common with the Old Testament concept of sin. Islam also recognizes the power of God to forgive the repenting sinner through his infinite mercy.

A sin, in Christian theology, is not only a deed but also a thought or desire in opposition to the eternal law of God. This is illustrated by the traditional teaching of the Seven Deadly Sins: pride, avarice, lust, envy, gluttony, anger, and sloth.

Sinai [sy'-ny] The Sinai is a triangular desert peninsula that forms a land bridge between Africa and Asia in northeast Egypt. It is bordered by the Gulf of Suez on the southwest, the Red Sea on the south, the Gulf of Aqaba on the southeast, and the Mediterranean Sea on the north. The Sinai has an area of 60,714 km^2 (23,444 mi^2) and reaches an altitude of 2,637 m (8,650 ft) at Mount Catherine.

Two-thirds of the Sinai is a great plateau sloping from an elevation of about 900 m (3,000 ft) to sea level at the Mediterranean. It becomes ruggedly mountainous to the south. Its most celebrated mountain is Sinai (Jubal Musa), on whose 2,286-m (7,500-ft) summit Moses is said to have received the Ten Commandments. The Sinai is intensely hot and receives less than 245 mm (10 in) of rainfall annually.

The Sinai's 200,493 inhabitants (1986 est.) include nomadic BEDOUIN, settled herders and farmers, and the residents of Egypt's only Palestinian refugee camp, adjoining the GAZA STRIP. Barley is cultivated on irrigated land, and fishing and tourism are important in coastal areas. Salt, coal, manganese, and petroleum from fields in the Gulf of Suez are extracted. In the 1980s several tunnels under the SUEZ CANAL were opened to link the Sinai to the rest of Egypt.

At its height, the ancient Egyptian empire encompassed northern and western Sinai. The peninsula was also important in biblical history. Saint HELENA founded the Monastery of Saint Catherine at Mount Sinai, which is still functioning. In 530, the Byzantine emperor Justinian commissioned a wall to be built around the structure. Despite the inhospitable terrain and climate, the peninsula has been of great strategic importance as an invasion route and has been a major battleground of the ARAB-ISRAELI WARS. As a result of the 1967 war, Sinai came under Israeli occupation. Under the terms of the Egyptian-Israeli peace treaty (1979), most of it was restored to Egypt in April 1982; Taba was returned in 1989.

Sinaloa [see-nah-loh'-ah] Sinaloa is a state in northwestern Mexico. Sloping from the Sierra Madre Occidental to a narrow coastal plain, the state has an area of 58,328 km^2 (22,521 mi^2) and a population of 2,210,766 (1990). The capital is CULIACÁN, and the main port is MAZATLÁN. Extensive mineral resources include silver and gold. The forested areas, rich in hardwoods and rubber trees, are undeveloped, and the agriculture centers are irrigated valleys that produce sugarcane, cotton, and citrus fruits. Conquered by the Spanish in 1531, Sinaloa became a state of Mexico in 1830.

Sinatra, Frank Singer and actor Francis Albert Sinatra, b. Hoboken, N.J., Dec. 12, 1915, burst onto the American popular music scene in the early 1940s, when his performances caused scenes of mass adulation equaled only by the American response to The Beatles 20 years later. Without any formal training, Sinatra evolved a highly sophisticated style. His ability to produce a long, flowing musical line unbroken by a pause for breath, his subtle use of the vocal techniques more commonly found in opera, and his manipulation of phrasing, reminiscent of Billie Holiday and Mabel Mercer, set him far above the usual run of pop singers. Moving from singing into acting, he won an Academy Award for his performance in *From Here to Eternity* (1953). He went on to star in several memorable films, including *Guys and Dolls* (1955), *High Society* (1956), *Some Came Running* (1958), and *The Manchurian Candidate* (1962). He continues on occasion to perform in films and in concert and to record.

Sinclair, Harry F. Harry Ford Sinclair, b. Wheeling, W.Va., July 6, 1876, d. Nov. 10, 1956, was a U.S. oil producer who founded the firm that bore his name. Sinclair started out to become a pharmacist and entered the drug business with his father. In 1901 he went into the oil business. He set up (1916) two oil firms: the Sinclair Oil and Refining Corporation and the Sinclair Gulf Corporation. He combined these enterprises into the Sinclair Consolidated Oil Corporation (later Atlantic Richfield) and in 1919 became its president. He was acquitted of bribery charges in the TEAPOT DOME scandal of 1928.

Sinclair, Upton The American novelist Upton Beall Sinclair, b. Baltimore, Md., Sept. 20, 1878, d. Nov. 25, 1968, is as famous for his social concern as for his novels. His first well-known novel, *The Jungle* (1906), exposed appalling conditions in the Chicago stockyards and influenced passage of the Pure Food and Drug Act. Sinclair subsequently tried and failed to exercise his socialism in a cooperative colony, but he persisted as a MUCKRAKER. He wrote about venereal disease (*Damaged Goods*, 1913), mining monopolists (*King Coal*, 1917), and Christian hypocrisy (*The Profits of Religion*, 1918, and *They Call Me Carpenter*, 1922). He criticized the shortcomings of American journalism in *The Brass Check* (1919) and the failures of American education in *The Goose-Step* (1923) and *The Goslings* (1924). Sensitive to political corruption and social injustice, he probed the Teapot Dome scandal (*Oil!*, 1927) and the Sacco-Vanzetti case (*Boston*, 1928). *The Wet Parade* (1931) is a fictional defense of prohibition. *Upton Sinclair Presents William Fox* (1933), which exposed financial chicanery in the film industry, was among the many works that Sinclair published himself when publishers refused them. In 1940 he published *World's End*, the first of 11 novels about Lanny Budd, who becomes the confidant of international leaders in the intrigues before and during World Wars I and II.

sine [syn] Sine is one of several critically important concepts in TRIGONOMETRY, a branch of mathematics that deals with triangles, especially right-angled triangles. It is customary to designate one of the acute angles in a right triangle as Θ. The "sine of the angle Θ" is a ratio: the length of the side opposite Θ divided by the length of the hypotenuse. The value of sine depends on—or is a function of—the size of the angle Θ; the sine is therefore called a trigonometric function. Because the sine can also be derived from a circle, with a radius of one unit, it is also called a circular function. In usage, *sine* is always abbreviated as *sin*.

Singapore [sing'-uh-por] The Republic of Singapore is an independent nation in Southeast Asia, located off the tip of the Malay Peninsula and connected to Malaysia by a causeway. Formerly a British crown colony and then part of the Federation of Malaysia, it became independent in 1965.

AT A GLANCE

REPUBLIC OF SINGAPORE

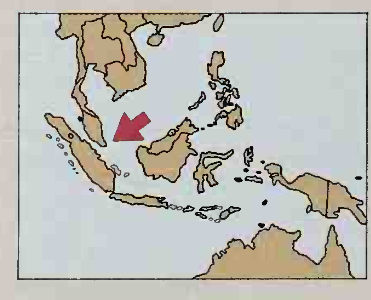
Land: Area: 618 km^2 (238.6 mi^2). Capital and largest city: Singapore City (1984 est. pop.,1,099,800).

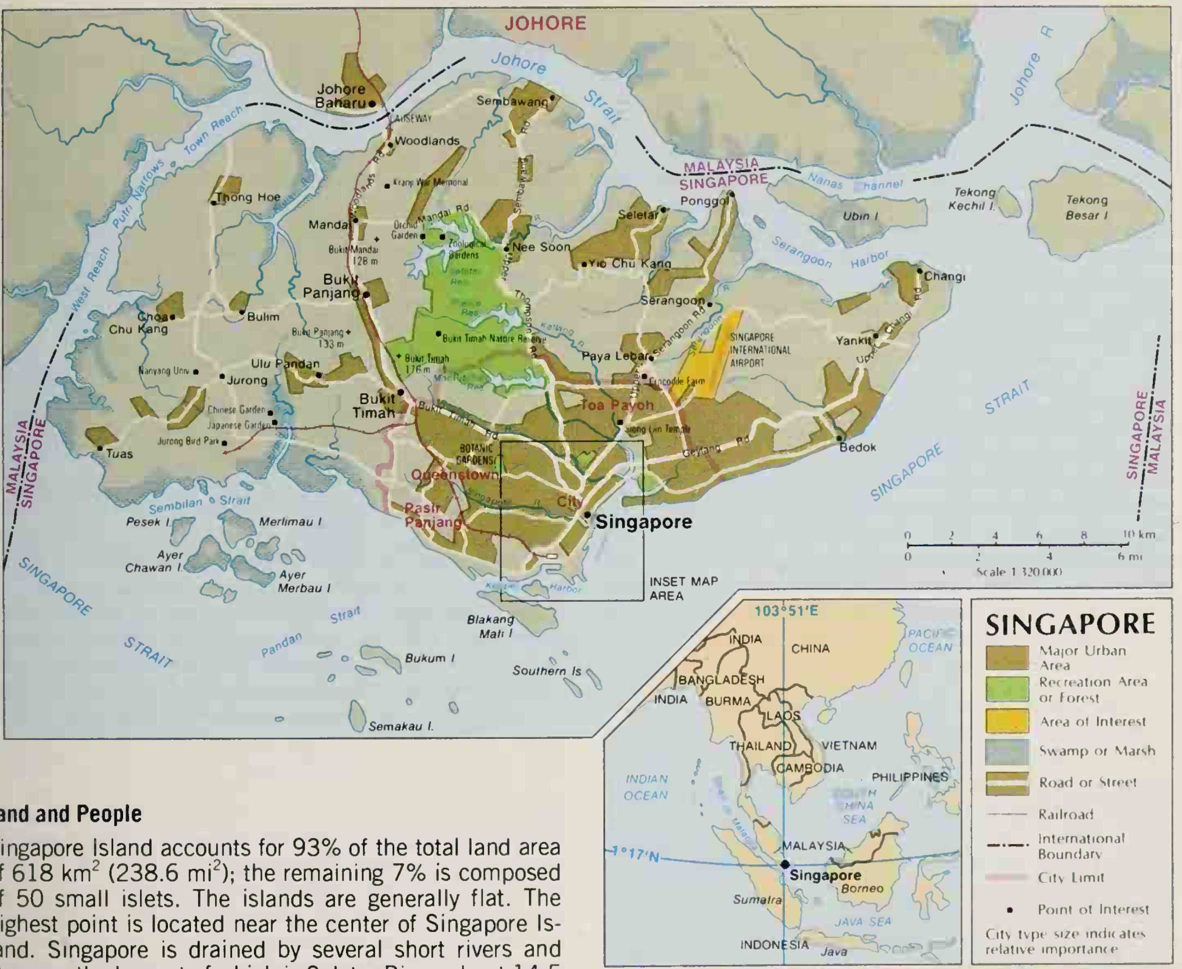
People: Population (1990 est.): 2,720,915. Density: 4,403 persons per km^2 (11,404 per mi^2). Distribution (1991): 100% urban. Official languages: English, Malay, Chinese, Tamil. Major religions: Buddhism, Daoism, Islam, Hinduism, Christianity.

Government: Type: republic. Legislature: Parliament. Political subdivisions: none.

Economy: GDP (1989): $29.19 billion; $10,810 per capita. Labor distribution (1990): commerce and services—62%; manufacturing—27%; construction—6%; government and public authorities—5%. Foreign trade (1989): imports—$51.1 billion; exports—$46 billion. Currency: 1 Singapore dollar = 100 cents.

Education and Health: Literacy (1989): 87.6% of adult population. Universities (1991): 1. Hospital beds (1988): 7,358. Physicians (1988): 3,612. Life expectancy (1990): women—77; men—72. Infant mortality (1990): 8 per 1,000 live births.





Land and People

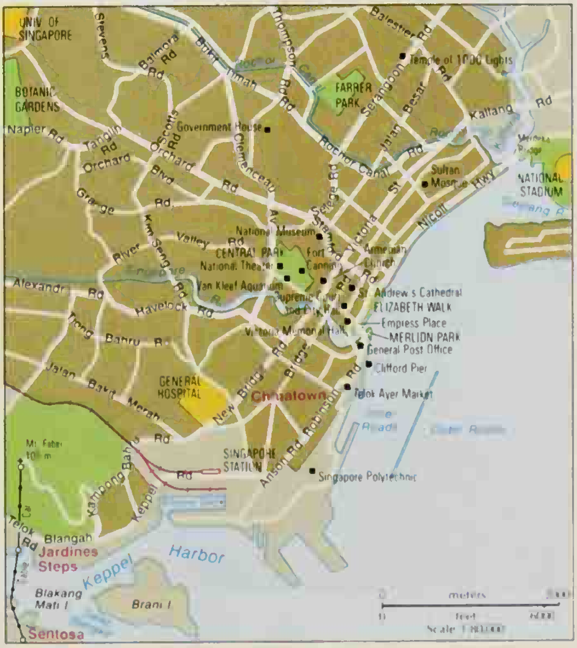
Singapore Island accounts for 93% of the total land area of 618 km^2 (238.6 mi^2); the remaining 7% is composed of 50 small islets. The islands are generally flat. The highest point is located near the center of Singapore Island. Singapore is drained by several short rivers and streams, the longest of which is Seletar River, about 14.5 km (9 mi) long.

Located about 110 km (70 mi) north of the equator, the nation has a tropical, wet climate. The average temperature in January is 26° C (79° F) and in July, 28° C (82° F); rainfall totals 2,413 mm (95 in) annually.

Singapore's principal resources are its strategic position on Singapore Strait and its people. Natural vegetation once consisted of forests and mangroves, but today only 10% of the land area is tree covered.

Singapore is a multiethnic nation; approximately 77% of its population are Chinese, 15% Malay, and 8% Indian, Pakistani, Sri Lankan, and others. English is the principal language of business, government, and education, and it is used by more than 25% of the adult population. Religious affiliation reflects ethnic background. Most Chinese are Buddhist or Daoist; Malays and Pakistanis are Muslim; most Indians are Hindu; and others are Christian.

Singapore's annual rate of population increase is the lowest in Southeast Asia as a result of a vigorous government-sponsored family planning program. Education is noncompulsory. Free universal primary school education is available. The National University of Singapore was es-



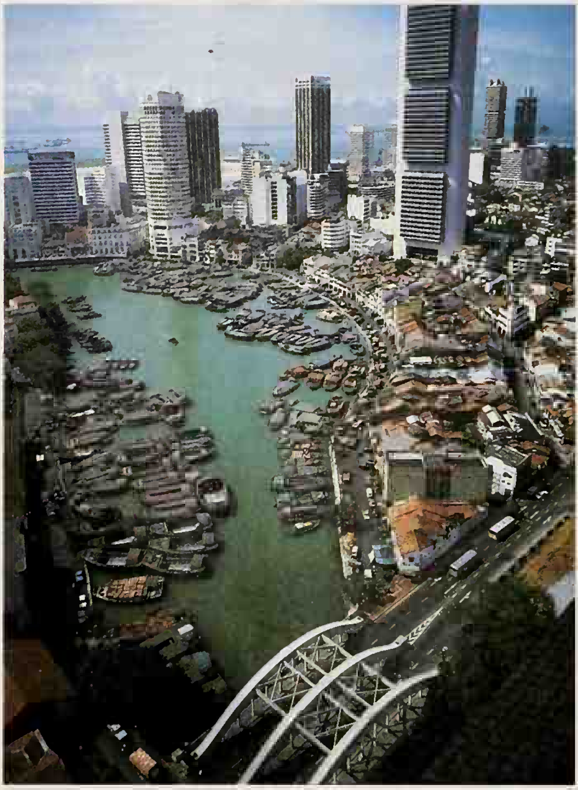
tablished in 1980, following the merger of the University of Singapore and Nanyang University.

Economic Activity

Singapore can trace its modern economic successes to its founding as an entrepôt because of its strategic position and excellent natural harbor. Initially it was a center for transshipment, but by the early 20th century primary goods—mainly rubber and tin from Malaysia—were being imported for processing. Major industries include petroleum refining, rubber processing, and the manufacturing of drilling equipment, food and beverages, and electronics. Since gaining independence Singapore has become a major industrial and financial center, and its port is now one of the largest in the world in terms of tonnage handled annually. Shipbuilding and ship repair constitute an important new industry.

Singapore has a trade surplus. Principal exports include petroleum products, rubber, machinery and transport equipment, timber, and electronic products. The major imports include rice, machinery, petroleum, and manufactures. Agriculture plays a minor role, but rubber and coconut trees are cultivated. The fishing industry is well developed. Singapore is self-sufficient in pork and poultry but must import much of its other food. Tourism is growing in importance.

Along the Singapore River is one of the world's leading ports. With a long tradition of commercial activity as an entrepôt, Singapore is a leading business and financial center in Southeast Asia.



Government and History

The republic has a parliamentary form of government in which cabinet members are drawn from the dominant political group in the legislature. Since 1959 politics has been completely dominated by the People's Action party headed by Prime Minister LEE KUAN YEW. The government is committed to multiracial harmony, anticommunism, internal stability, and economic modernization. Its foreign policy is based on nonalignment.

Little is known about early Singapore, but a town named Temasek existed on the island as early as the 11th century. In 1819, Sir Thomas Stamford RAFFLES arrived. He saw the strategic advantages of the location and urged Britain to purchase the territory. In 1824 it was established as a major British trading post in Southeast Asia. Chinese and Indian traders, Indian indentured laborers, and Malays began arriving in large numbers, and the population increased rapidly. By 1836 the Chinese outnumbered all other groups. In 1830, Singapore became a part of the Straits Settlements, which, in 1867, were made a British crown colony. In February 1942, Singapore fell to the Japanese. Restored to British rule in 1945, it was constituted as a separate crown colony the following year. Internal self-government began in 1959, and in 1963, Singapore became a semiautonomous state within the Federation of Malaysia. On Aug. 9, 1965, Singapore was separated from Malaysia and became an independent republic within the Commonwealth of Nations. Since then it has become an industrial and financial power with one of the highest standards of living in Asia. The government plays a major role in managing the economy, and a brief slowdown in the early 1980s sparked criticism of government paternalism and the lack of public debate. Opposition parties received more than 35% of the vote in 1984 and 1988. Lee retired as prime minister in November 1990 but remained party leader. Goh Chok Tong became prime minister, with Lee's son as first deputy.

Singer, Isaac Bashevis The most widely known and possibly the last of the great Yiddish-language fiction writers, Isaac Bashevis Singer, b. Radzymin, Poland, July 14, 1904, d. July 24, 1991, emigrated to the United States in 1935 and in 1978 won the Nobel Prize for literature. He began his New York career as a journalist for the *Jewish Daily Forward*, where much of his fiction was published first. Singer himself supervised the translation of his works from Yiddish into English.

Singer's famous trilogy, *The Family Moskat* (1950), *The Manor* (1967), and *The Estate* (1970), is a family epic that traces the history of the Jews in Poland from the antitsarist uprisings of 1863 to World War II. (Singer's older brother, writer Israel Joshua Singer, 1893–1944, produced an equally famous family epic, *The Brothers Ashkenazi*, in 1936.) Much of the power of Singer's work lies in his authentic recreation of the seemingly timeless world of eastern European Jewry—a charmed world that

Isaac Bashevis Singer, awarded the 1978 Nobel Prize for literature, was the dean of modern Yiddish letters. In brilliantly crafted novels, short stories, and plays Singer evoked the manners, morals, and mystical leanings of the pre–World War II Jewish communities of eastern Europe. "Gimpel the Fool" (1957) and "The Spinoza of Market Street" (1961) are among his best-loved stories.

Photo Jill Krementz © 1978

remains alive for many readers only through his works. A born storyteller, he was usually at his best in his short stories, which were republished in his *Collected Short Stories* (1982). He wrote many books for children. His autobiographical works were published under the title *Love and Exile* (1984). His novel *Enemies: A Love Story* (1987) appeared as a film in 1989.

Singer, Isaac Merrit The inventor of the first practical sewing machine, Isaac Merrit Singer, b. Pittstown, N.Y., Oct. 27, 1811, d. July 23, 1875, also created the world's first consumer-appliance industry, and devised such modern business methods as installment buying and the advertising campaign. Singer left home at the age of 12 to become an itinerant machinist. In 1851 he designed a sewing machine that embodied most of the basic features still used on modern machines. Although embroiled in a patent infringement suit brought by Elias Howe, who had developed a similar model, Singer founded a company that became the world's largest manufacturer of sewing machines by 1860. He was awarded 20 additional patents, spent millions of dollars advertising his machine, promoted installment credit, and initiated a system of providing service with sales.

Singh, V. P. Vishwanath Pratap Singh, b. June 25, 1931, was prime minister of India from Dec. 2, 1989, to Nov. 7, 1990. Formerly chief minister of Uttar Pradesh state (1980–82) and a cabinet member under Indira Gandhi (1974–77 and 1982–84) and Rajiv Gandhi (1984–87), he was expelled from the Congress-I party in 1987. Named head of the new opposition National Front and its Janata Dal faction in 1988, he became prime minister after Congress-I lost the 1989 elections. Singh had to resign when his fragile coalition collapsed; he was succeeded by Chandra Shekhar.

single tax The single tax is a proposed levy on land rents as the sole source of government revenue. The idea of a single tax was introduced by the physiocrats, an 18th-century school of French economists, and was popularized by an American economist-reformer, Henry George. His treatise *Progress and Poverty* (1879) sold in the millions throughout the world. According to George, the use of a single tax would remove unearned incomes and thus provide the basis for greater equality without destroying the incentive to produce.

George argued that landlords do not contribute to production by their ownership of natural resources but profit from the efforts of others who make their land valuable by raising the demand for it. An annual levy could therefore withdraw this unearned surplus without harm to society as a whole. George's single-tax proposal has influenced modern progressive taxation in Australia, Canada, the United States, and several Western European countries.

Sinhalese [sing'-guh-leez] The Sinhalese are the dominant ethnic group in Sri Lanka (formerly Ceylon); they numbered approximately 12 million people in the mid-1980s. They speak an Indo-European language related to Sanskrit and Pali, and their myths are of a North Indian ancestry. Most Sinhalese are Theravada Buddhists, although their religion also involves gods of Hindu origin. Sinhalese society is organized in a series of castes similar to those of India but less rigid and with no Brahman or Kshatriya castes. The largest and highest of the Sinhalese castes is the Goyigama, whose members are traditionally cultivators. The preferred form of Sinhalese marriage is between the children of a sister and a brother. Sometimes a man marries more than one woman or a woman has more than one husband.

From the 16th century on, the coastal areas of Sri Lanka were under European control, and from 1815 until the country's independence in 1947 the entire island was in British hands. As a result of foreign rule and Christian influences, traditional Sinhalese culture is considerably eroded.

Sinkiang see Xinjiang

Sinn Fein [shin fayn] Sinn Fein (Irish for "we ourselves") was an Irish nationalist movement founded in 1905 by Arthur Griffith. As an alternative to the militant republicanism of the Fenians and the parliamentary nationalism of John Redmond, Sinn Fein favored withdrawal of Irish members from the House of Commons and passive resistance to British rule.

After a brief vogue among Dublin intellectuals, Sinn Fein virtually disappeared because of the apparent progress (1910–14) of Redmond's Irish party toward achieving home rule. When journalists inaccurately described the 1916 Easter Rising as the "Sinn Fein rebellion," the term caught on as a way to describe disillusionment with the Irish party. In 1917, Sinn Fein was reconstituted as a mass political party led by Eamon DE VALERA, and a year later it won nearly all the parliamentary seats from districts with Catholic majorities.

The Sinn Fein members of Parliament established a revolutionary legislature (Dáil Eireann) in Dublin. The movement split over the question of Irish partition in 1921 and largely disintegrated in the aftermath of the Irish civil war. Sinn Fein survived as a minority party in the Irish Free State and the Republic of Ireland, refusing to recognize the legitimacy of the Dublin government and associating itself with the IRISH REPUBLICAN ARMY. It is not represented in the Irish parliament, but it later became active in Northern Ireland.

Sino-Japanese Wars In modern times China and Japan have fought two major wars. The first (1894–95) marked Japan's emergence as a major military power; the second (1937–45) ended with Japan's defeat in World War II.

The **First Sino-Japanese War** developed out of rivalry for control of Korea. In 1876, Japan forced Korea to assert independence from its longtime suzerain China and open itself to foreign trade. Chinese attempts to counter rising Japanese influence there made Korea a center of intrigue. Finally, in 1894 a Korean rebellion resulted, and both China and Japan dispatched troops. The war began on Aug. 1, 1894, and the Japanese army quickly routed the larger Chinese forces. By the Treaty of Shimonoseki (April 1895), China recognized Korean independence and ceded Taiwan, the Pescadores, and Liaodong Peninsula of Manchuria to Japan, but European pressure forced the return of the Liaodong Peninsula to China.

The **Second Sino-Japanese War** resulted from direct Japanese aggression against China. In 1931, Japanese officers staged the Mukden Incident—a bombing of the Japanese-controlled South Manchurian Railroad—which Japan used as a pretext for overrunning Manchuria and establishing the puppet state of Manchukuo. Full-scale war broke out in July 1937. Within 18 months the Japanese conquered most of eastern China, forcing the Chinese government to retreat to Chongqing. The United States and Britain began (1938) to send aid to the Chinese government of CHIANG KAI-SHEK. From 1939, Japan turned its attention to Southeast Asia, and after 1941 the conflict became part of WORLD WAR II. The Japanese occupation of China ended only after Japan's surrender in 1945.

See also: CHINA, HISTORY OF; JAPAN, HISTORY OF; KOREA, HISTORY OF.

Sino-Tibetan languages The Sino-Tibetan language family consists of the Chinese, or Sinitic, languages, all spoken in China (see CHINESE LANGUAGE), and several hundred Tibeto-Burman languages spoken from Pakistan to Vietnam. The most important of the Tibeto-Burman group are Tibetan, the dominant language of Tibet, and Burmese, the official language of Burma. Both Vietnamese and the Tai and Miao-Yao (now sometimes called Hmong-Mien) languages of Thailand, Laos, Vietnam, and southern China were once mistakenly classified as Sino-Tibetan. Vietnamese belongs to the Mon-Khmer family, whereas Tai, together with the related Kam-Sui and Kadai languages of southern China, is a distinct family, now called Kadai. The affiliations of the Miao-Yao group remain unclear; they may be affiliated with either the Sino-Tibetan or the Kadai family. The common vocabulary and structural similarities among the Chinese, Kadai, Miao-Yao, and Vietnamese languages (most of which are not shared with Tibeto-Burman) reflect not a genetic relationship but a long period of close linguistic and cultural contact. (See SOUTHEAST ASIAN LANGUAGES.)

Chinese has a writing system and a literary tradition going back more than 2,500 years. Most of the Tibeto-Burman languages are unwritten, but several have indigenous alphabets adapted from the Indian tradition. Tibetan has written records dating to the 7th century, and Burmese and Newari, the former state language of Nepal, have written traditions dating from the 12th and 13th centuries. The Lepcha language of Sikkim and the Meithlei language of Manipur (states in India), have written traditions of which little is known. The extinct Tangut language of northwestern China had a writing system modeled after but quite distinct from Chinese, while some Yi (Lolo) and Naxi (Moso) groups in Yünnan possess a pictographic script, apparently of considerable age, probably inspired by Chinese.

The Tibeto-Burman Languages. Aside from the dominant languages of Tibet and Burma, the Tibeto-Burman branch includes an undetermined number of smaller languages spoken in Pakistan, India, Nepal, Bhutan, Bangladesh, northern and western Thailand, and the Yünnan and Sichuan provinces of China. There are four major subbranches. The Western (or Bodic) branch includes Tibetan and most of the languages of the Himalayas. Tibetan dialects are spoken from northern Pakistan and Kashmir (Balti and Ladakhi) eastward to Qinghai province in China. The most important of the other languages in this branch are Newari, still the dominant language of the Katmandu valley, and the Kiranti languages of eastern Nepal. Several other languages of this branch are spoken along the northern edge of Himachal Pradesh in northwestern India. The Kamarupan branch includes languages spoken in Assam, Arunachal Pradesh, and Mizoram in India; the most important are the Bodo-Garo languages of Assam, the Kuki-Chin languages of India, Bangladesh, and western Burma, and the Naga languages of Arunachal Pradesh. The Eastern (or Burmic) branch includes Burmese and the other Lolo-Burmese languages of Burma, Thailand, and Yünnan, and perhaps several other languages of Yünnan and northern Burma. There are many speakers of Loloish languages (Yi, Lahu, Lisu, and others) in Yünnan, and smaller numbers in northern Burma, Thailand, and northwestern Vietnam. The Karen branch includes a small number of closely related languages spoken along the Burma-Thailand border. The division of Tibeto-Burman into four major branches may be nearly as old as the original division of Chinese and Tibeto-Burman, which occurred about 4,000–5,000 years ago.

Characteristics of the Sino-Tibetan Family. The Tibeto-

Burman languages show much more structural diversity than the Chinese languages, for there are many more than 400 of them, and they are less closely related to one another. Except for Karen, most of the Tibeto-Burman languages are structurally quite unlike Chinese. In Chinese and Karen, the word order of sentences is subject-verb-object, just as in English. In most of the other Tibeto-Burman languages the order is subject-object-verb. The Tibeto-Burman languages also tend to have or allow fairly long strings of verbs, auxiliary verbs, and verb particles. They also show a pattern of discourse organization known as clause chaining, in which sentences can be of a length and complexity comparable to paragraphs in Western languages.

Some Tibeto-Burman languages have fairly complex sets of affixes in the verb, marking agreement for person and number with the subject or object or both. Because of the clear relationship between these agreement markers and the independent pronouns, these languages are often referred to as "pronominalized." Many languages of the family are "ergative," placing case-marking on the subject of a transitive verb, rather than on the object as in most European languages, and leaving transitive objects and intransitive subjects unmarked. Most of these are "split ergative," with case-marking on third-person transitive subjects but not first or second.

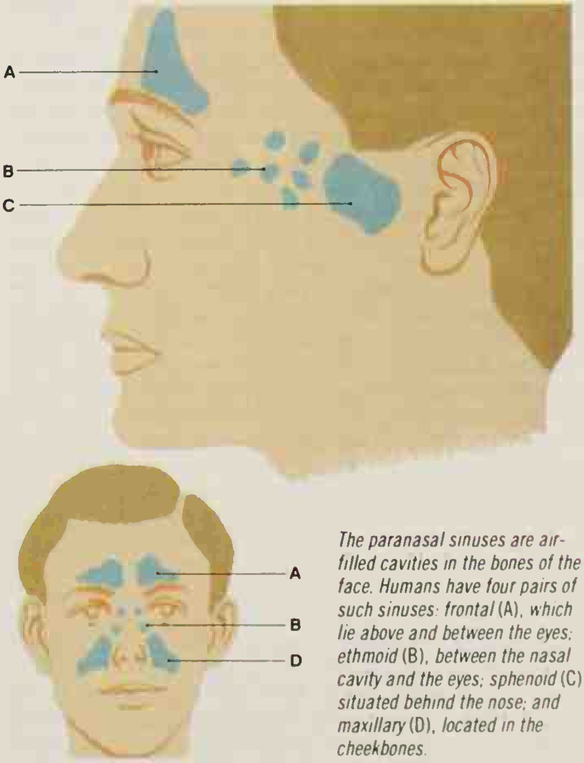
Many Tibeto-Burman languages are tone languages, in which differences in pitch and pitch contour can change the meanings of words—but this seems to be a secondary feature; it is probable that Proto-Tibeto-Burman—and presumably Proto-Sino-Tibetan—lacked tones. Tone systems have developed independently in many of the daughter languages largely through simplifications in the set of possible syllable-final and syllable-initial consonants.

The Chinese language is monosyllabic—that is, virtually all meaningful units in Chinese are a single syllable. Few of the Tibeto-Burman languages are monosyllabic in the sense that Chinese is. Most of them contain many unanalyzable polysyllables—polysyllabic units such as the English word *water*, in which the individual syllables have no meaning by themselves. In a true monosyllabic language polysyllables are mostly confined to compound words, such as *lighthouse*. Most Tibeto-Burman languages do show a tendency toward monosyllabicity, however, in that the first syllables of compounds tend over time to be destressed, and may eventually reduce to prefixed consonants. Virtually all polysyllabic morphemes in Tibeto-Burman languages can be shown to originate in this way. For example, the disyllabic form *bakhwán*, "butterfly," which occurs in one dialect of the Trung (or Dulung) language of Yünnan, is clearly a reduced form of the compound *blák kwár*, found in a closely related dialect. The first element of this compound, in turn, is itself a reduction of an old compound of two roots, *ba* or *ban* and *lak*, both meaning "arm," "limb," and often turning up in forms for "wing." This is also the origin of many of the famous consonant clusters of written Tibetan.

Sinop [suh-nawp'] Sinop (Greek: Sinope), the capital of Sinop province, northern Turkey, is located on a peninsula 121 km (75 mi) northwest of Samsun; it has a population of 23,148 (1985). Founded by colonists from Miletus in the 8th or 7th century BC, it was the leading naval power of the Black Sea in the 5th century BC and the mother city of Trabzon (Trapezus) and other Greek colonies in the area. One of its main exports was sinopite, or sinopic earth, a red clay used as a pigment. In the 2d century BC, Sinop became the capital of the kingdom of PONTUS and enjoyed its greatest prosperity under King MITHRADATES VI (r. 120–63 BC); it was captured and destroyed (70 BC), however, when Mithradates was defeated by the Romans. The city was refounded as a Roman colony by Julius Caesar, but it never regained its former importance.

sinter Sinter, a porous mineral deposit usually formed in thermal waters, may be composed of either opaline silica or calcium carbonate. Silica-rich sinter (geyserite) is deposited largely through the action of algae and occurs as crusts near hot springs and geysers, sometimes forming conical mounds or terraces. Travertine and other calcareous sinter (sometimes called tufa) is precipitated in thermal waters by mosses and other organic matter. Common in limestone districts, travertine was the principal building stone of ancient Rome.

sinus The term *sinus* (a "channel" or "hollow space") is defined as any cavity within a bone but is most often



The paranasal sinuses are air-filled cavities in the bones of the face. Humans have four pairs of such sinuses: frontal (A), *which lie above and between the eyes; ethmoid* (B), *between the nasal cavity and the eyes; sphenoid* (C), *situated behind the nose; and maxillary* (D), *located in the cheekbones.*

used to identify the mucus-lined air cavities in the facial bones and certain blood passageways in animals. In humans, sinuses surround the nose and are known as the paranasal sinuses. They extend from the nasal cavities into adjoining bones and are connected to the nose by passageways. The paranasal sinuses are thought to help warm and moisten inhaled air. They also reduce the weight of the skull and perhaps modify vocal sounds. The bones that contain sinuses are the frontal, sphenoid, ethmoid, and maxillary bones.

The paranasal sinuses are lined with a mucosa, or moist membrane. Glands are present within the mucosa, and ciliated and goblet cells occur on the surface, exposed to the air space in the sinus. The ciliated cells exhibit hairlike processes that beat back and forth. They serve to keep the air that enters the lungs clean by trapping dust and dirt. The particles and mucus eventually reach the pharynx and are swallowed. An inflammation of the mucosa is called SINUSITIS.

Sinuses in blood passageways include the capillary spaces of the liver; spaces in the common carotid artery and the aorta; and maternal sinusoids, which are small channels in the wall of the uterus of a pregnant woman.

sinusitis Sinusitis generally refers to inflammation of mucous membranes of the paranasal sinuses, which are bone cavities located in the skull near the nose. They include the frontal sinuses, located above the orbits of the eyes; the maxillary sinuses, located in the cheekbones; and the ethmoid and sphenoid sinuses, located behind the nose. All of these sinuses drain mucus into the nose through small channels. Inflammation of the sinuses results from an infection or an allergy. Infection is caused by the introduction of bacteria through interconnecting channels and is accompanied by pain and tenderness. Chronic sinusitis may be infective, allergic, or a combination of these forms.

Maxillary sinusitis often occurs after a cold or after swimming in contaminated water. Occasionally, extraction of a molar tooth will break the floor of the maxillary sinus, leaving an opening through which bacteria can enter and cause sinusitis. Frontal sinusitis usually is accompanied by localized headache, surface tenderness, and, occasionally, swelling of the eyelids; these symptoms also occur in ethmoid sinusitis. Sphenoid sinusitis often causes blurring of vision because of the proximity of this sinus to the optic nerves.

The proximity of these sinuses to the brain makes all paranasal sinusitis potentially dangerous. The usual treatment is with antibiotics, although surgical procedures are sometimes necessary to facilitate drainage and relieve pressure.

Sinyavsky, Andrei [seen-yahv'-skee] A Russian writer and scholar, Andrei Sinyavsky, b. Oct. 8, 1925, was imprisoned in 1966 following his trial with Yuri Daniel, after several of his works, unpublishable in the USSR, appeared in print abroad under the pseudonym Abram Tertz. The most notable of these was *The Trial Begins* (1959; Eng. trans., 1960), a novel remarkable for its psychological subtleties. Released in 1971, Sinyavsky later moved to Paris.

Sioux [soo] The Sioux are a group of North American Indian tribes of the Great Plains area. Their Siouan language is spoken in various dialects by tribes across the United States. The three main Sioux groups are the Lakota to the west, the Dakota to the east, and the Nakota between them. Each group is composed of several bands. The Lakota, or Teton Sioux, include the Oglala, Brule, Hunkpapa, Minneconjou, Itazipcho, Oohenonpa, and Sihasapa (Blackfeet). Together, the Sioux numbered about 30,000 in the mid-18th century. To the Sioux, fighting was in many ways a game based on valor and bravery; they might simply touch an adversary, representing a kill, and let him live. Prestige was won through deeds, which were validated by a recital of the facts, because truthfulness was a paramount virtue. Sioux culture is characterized by mobility on horseback, a buffalo economy, vision quests, soldier societies, and the SUN DANCE.

After the Sioux massacre at WOUNDED KNEE (1890), they remained on reservations in Minnesota, Nebraska, the Dakotas, and Montana and in the Canadian provinces of Manitoba and Saskatchewan. Sioux leaders in the AMERICAN INDIAN MOVEMENT in 1973 protested against reservation abuses by taking over the village of Wounded Knee, S.Dak. Sioux on or near reservations in the United States number about 70,000 (1989 est.).

Sioux City Sioux City lies on the Missouri River in northwestern Iowa, at the Iowa–Nebraska–South Dakota border. The seat of Woodbury County, Sioux City has a population of 80,505 (1990). The city is the market center for the surrounding agricultural area. Trucks, tractors, machine products, fertilizers, and feed are produced there. Morningside College (1893) and Briar Cliff College (1930) are located in the city. The Lewis and Clark Expedition visited the site in 1804. Settled in 1848, Sioux City was incorporated under its present name in 1857.

Sioux Falls Sioux Falls, the largest city in South Dakota and a commercial and distribution center, lies at the falls of the Big Sioux River in the southeastern part of the state, 27 km (17 mi) west of the Minnesota–Iowa–South Dakota border. The seat of Minnehaha County, it has a population of 100,814 (1990). The city's stockyards, slaughterhouses, and meat-packing and food-processing plants serve the tri-state area. Granite quarries and a nuclear power plant are located nearby. Sioux Falls has two colleges, a seminary, a school for the deaf, and several vocational and business schools. Brandon Mounds, an Indian burial site, is about 32 km (20 mi) to the east.

The city was settled in 1857, abandoned in 1862 after the Sioux uprising, and resettled upon the building of Fort Dakota in 1865. The first railroad arrived in 1878.

siphon A siphon is a tube or pipe that will conduct a liquid from an intermediate level over a higher level to a lower level so long as no air is admitted to the siphon between the intermediate and higher levels. The hose used to drain an automobile gas tank is a common form of siphon. The Greeks and Romans used lead pipe siphons to convey drinking water over heights, and huge siphons are used in modern water-supply systems. Whatever the siphon's size, its working principle remains the same. The tube must be full of liquid from the upper end, which is inserted into the liquid container, and past the tube's highest point. The lower end of the tube must be below the container's liquid level. Because the pressure in the upper, shorter neck of the siphon is greater, the liquid will flow from the intermediate level up over the higher level and down to the lower. Flow is easily started in small tube siphons by applying suction briefly to the lower end.

Sippar [sip-ahr'] The ancient Sumerian city of Sippar (modern Abu Habba) lies 32 km (20 mi) southwest of Baghdad, Iraq. Traditionally one of the five antediluvian cities, it was also important as a center of worship of the sun-god Shamash. Probably occupied before 3000 BC, the city came under the control of the Old Babylonian dynasty from 1838 to 1595 BC. Sippar continued to flourish despite successive political upheavals until it surrendered (539 BC) to Achaemenid king Cyrus the Great. The Shamash Temple, a large rectangular precinct measuring 320 by 240 m (1,050 by 790 ft), was restored by Akkadian king Naram-sin (r. 2291–2255 BC). An important cuneiform archive has yielded information on all aspects of city life during Old Babylonian times.

Siqueiros, David Alfaro [see-kay'-rohs] David Alfaro Siqueiros, b. Dec. 29, 1896, d. Jan. 7, 1974, was one of Mexico's leading 20th-century painters. His art went hand in hand with his commitment to socialism and revolution. In 1919 he published (in the single issue of his *Vida Americana*) a manifesto calling for a new, heroic people's art based on that of the pre-Hispanic cultures, then organized the group of revolutionary artists later identified with the muralist school. His own earliest murals were painted in the National Preparatory School in Mexico City (1922–24). Siqueiros developed his dramatic personal style during the 1940s and '50s, making use of exaggerated perspective and other optical devices, surrealist themes, and montage. Often he combined painting, sculpture, and architecture to produce dynamically bold synthetic effects. His more important works include those in the Palace of Fine Arts (1945–50) and the National University of Mexico (1952–56) and his masterpiece, *The March of Humanity*, in the hotel Parque de la Lama (1968), all in Mexico City.

Sir Gawain and the Green Knight [gow'-wuhn] *Sir Gawain and the Green Knight* (*c.*1360–1400) is a Middle English alliterative romance written by an anonymous West Midlands poet also credited with *The Pearl*, *Patience*, and *Purity*, or *Cleanness*. The protagonist, Sir Gawain, survives two tests: a challenge, which he alone of King Arthur's knights accepts, to behead the fearsome Green Knight and to let him retaliate a year later at the distant Green Chapel; and a temptation to commit adultery with the wife of Lord Bertilak—in reality the Green Knight—in whose castle he stays en route to the chapel. Memorable for its superb portrait of Gawain, the poem contains elaborate descriptions of Arthur's feast, Gawain's lonely journey, and Bertilak's hunting excursions.

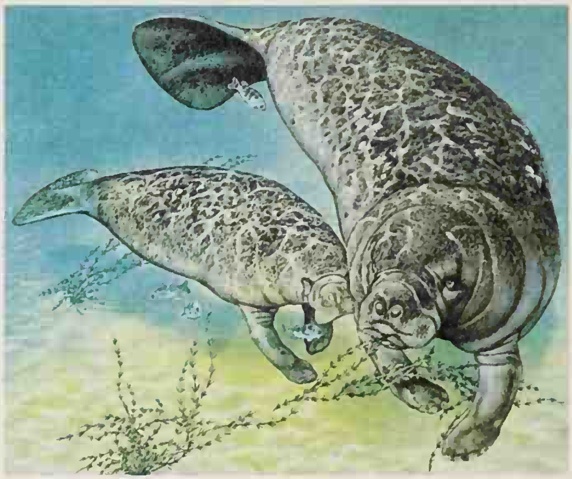
Sirach, Book of The Book of Sirach, or the Wisdom of Jesus the son of Sirach, is a book in the APOCRYPHA. It is also known as Ecclesiasticus ("church book") because of its wide use among Greek and Latin Christians in moral instruction. Classified among the wisdom writings, the book was written in Hebrew at Jerusalem *c.*180 BC by a learned teacher, Jesus ben Sirach, and was translated into Greek in Egypt with a preface by his grandson not long after 132 BC.

The wisdom teaching of the book is climaxed by a long eulogy of the heroes of Israelite history. Using the sayings form typical of the Book of Proverbs, the author achieves a fusion of scribal piety, with its high regard for the Jewish law, and traditional wisdom.

siren [sy'-ruhn] Sirens, aquatic amphibians of southeastern North America, have eel-shaped bodies, small forelimbs with three or four toes on each, and no hind limbs. Although adult sirens develop lungs, they retain certain larval characteristics throughout life, such as external feathery gills and lidless eyes. The siren family, Sirenidae, frequently classified in the salamander order Caudata or Urodela, contains three species. The great siren, *Siren lacertina*, is one of the largest amphibians, reaching more than 90 cm (36 in) in length.

Sirenia [sy-ree'-nee-uh] A mammalian order, Sirenia comprises two living families: the dugongs, or sea cows, family Dugongidae, with one species, *Dugong dugon*; and the manatees, family Trichechidae, with three species in the genus *Trichechus*. Steller's sea cow, *Hydrodamalis stelleri*, was a species of dugong found in the Arctic in 1741 by the explorer Vitus Bering but exterminated by 1768 through overhunting. Once cosmopolitan in distribution, sirenians are now confined to tropical coastal waters and estuaries (marine and freshwater).

Sirenians are fishlike in shape, and the body is almost devoid of hair. The forelimbs are flippers, and the tail is a horizontally flattened fin; hind limbs and dorsal fins are absent. The eyes are small, the ears are not external, and the nostrils can be closed by sphincters. Sirenians breathe by frequent visits to the surface. They graze on aquatic vegetation. Dugongs grow up to 3.5 m (12 ft) in length and weigh more than 350 kg (770 lb). The mana-



The manatee Trichecus manatus *is a sirenian found primarily in shallow coastal rivers and estuaries in Florida and along the Caribbean and Gulf coasts to northern South America.*

tees reach 4.5 m (15 ft) in length and weigh about 650 kg (1,430 lb). They are less adapted to aquatic life than is the dugong, and they have some body hair and have nails at the tips of their flippers.

Dugongs and manatees mate in February and March in shallow water. Gestation lasts about a year.

Sirens In Greek mythology the Sirens sang melodies so beautiful that sailors passing their rocky island were lured to shipwreck and death. Homer, in the *Odyssey*, mentioned two Sirens; later, in the tales of the Argonauts, three are mentioned, each having the head of a woman and the body of a bird. ODYSSEUS ordered his men to stop their ears with beeswax so that they could not hear the Sirens' songs and to tie him to the ship's mast so that he could not swim ashore. JASON and the Argonauts were saved when Orpheus, who accompanied them, played music that was even more enchanting. The jealous Sirens then jumped to their deaths in the sea.

Sirhan, Sirhan see KENNEDY, ROBERT F.

Sirius [sir'-ee-uhs] Bluish-white Sirius is the brightest STAR in Earth's sky besides the Sun. Its name derives from Greek for "sparkling," but the star appears in many mythologies and was known to the ancient Egyptians as Sothis and to the Arabs as Al Shira. Also known as the Dog Star, it lies in the constellation CANIS MAJOR; the term "dog days" refers to its rising with the Sun during the hottest time of year.

With an apparent magnitude of −1.47 and lying 8.7 light years away—the 6th-nearest known star—Sirius has an absolute magnitude of +1.4; it is a fairly typical A1-type star (see STELLAR EVOLUTION). In 1844 it was found to be a BINARY STAR; its faint companion, half as massive, was sighted in 1862 and, in 1915, became the second star identified as a WHITE DWARF. The system has a rotation period of nearly 50 years and a total mass of 3.29 solar masses. Ancient records describe Sirius as reddish, raising conjectures about the binary's evolution to account for this apparent change.

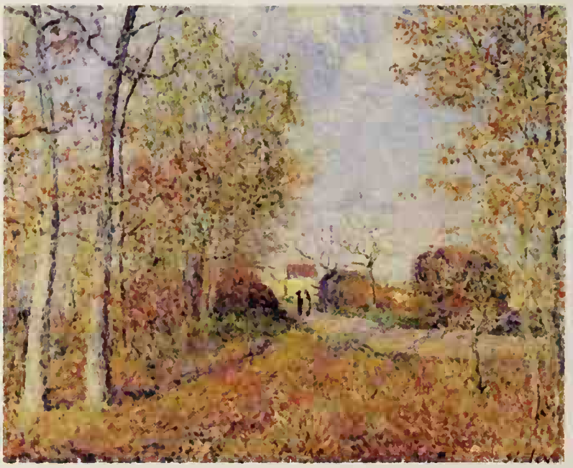
sirocco [suh-rah'-koh] The sirocco (from the Arabic *shoruq*, "from the east") is a warm, humid, southerly wind of the Mediterranean Sea. The sirocco originates as hot, dry air over the northern coast of Africa; the hot, dry wind forms ahead of a depression advancing across North Africa and the southern Mediterranean Sea. After picking up moisture as it crosses the Mediterranean, the sirocco brings rain and fog to southern Europe.

sisal see HEMP

Sisler, George George Harold Sisler, b. Manchester, Ohio, Mar. 24, 1893, d. Mar. 26, 1973, was an American professional baseball player from 1915 to 1930. He began his career with the St. Louis Browns as a first baseman and developed into one of the most consistent hitters in history. For the years 1920–22 he batted .407, .371, and .420, respectively, and in 1920 he set the single-season record for hits with 257. Sisler had a lifetime batting average of .340, and he struck out only 327 times in 8,267 times at bat. An accomplished fielder, he also led the American League in stolen bases four times. Sisler was elected to the Baseball Hall of Fame in 1939.

Sisley, Alfred [sees-lay'] The French impressionist painter Alfred Sisley, b. Oct. 30, 1839, d. Jan. 29,

Road at the Edge of the Woods *(1883) is typical of the impressionist landscape painter Alfred Sisley. (Musée d'Orsay, Paris.)*



1899, produced innumerable small paintings of the countryside near his home as well as charming, sunny townscapes. Although his family was English, Sisley spent most of his life in France. In the early 1860s he met and became friends with Claude Monet, Pierre Auguste Renoir, and Fréderic Bazille. Together they developed a style of landscape painting marked by casual composition and a lightened palette that came to be called impressionist. They generally painted out of doors—an unusual practice at that time. Initially influenced by Camille Corot, Sisley settled into his own quiet, lyrical style from the 1870s through the 1890s. His subject was always landscape. There is little change between *La Seine à Bougival* (*c.*1872; Yale University Art Gallery, New Haven, Conn.) and *Au Bord du Loing* (1892; Louvre, Paris) apart from looser handling and stronger color. Sisley failed to achieve success—either critical or financial—during his lifetime.

Sismondi, Jean Charles Léonard Simonde de [sees-mohn-dee'] Jean Charles Léonard Simonde de Sismondi, b. May 9, 1773, d. June 23, 1842, was a Swiss economist and historian. A one-time follower of Adam Smith, Sismondi later modified his views, and in *Nouveaux Principes d'economie politique* (New Principles of Political Economy, 1819) he urged the regulation of competition and protection of the poor. He also wrote about the literature of southern Europe and produced a multivolume history of France. His most enduring work, *The History of the Italian Republics in the Middle Ages* (16 vols., *c.*1807–18; Eng. trans., 1831), showed the greatness of Italy in the era of its free cities and became an inspiration to Italian nationalists.

Sister Carrie *Sister Carrie* (1900), one of the finest works of American literary NATURALISM, was Theodore DREISER's first novel. Its frank depiction of the lower orders of society was unacceptable to the reading public and caused its withdrawal from circulation by the publisher. Dreiser's sympathetic portrayal of Carrie, a naive country girl who becomes a successful actress after taking advantage of the support offered by two lovers, offended conventional morality. The first edition of the book was expurgated by Dreiser's wife, Sara, and his friend Arthur Henry, but a new edition (1981) restored Dreiser's original text.

Sistine Chapel The Sistine Chapel is the private, official papal chapel where conclaves for the election of popes are traditionally held. It was built (1473–81) under the supervision of Giovanni de Dolci for Pope Sixtus IV (r. 1471–85), and its decoration involved several generations of artists working for a number of popes. A marble screen and cantoria are attributed to the workshop of Andrea Bregno.

The Sistine Chapel, decorated with biblical frescoes by Botticelli, Ghirlandaio, and other Renaissance artists, is crowned by Michelangelo's ceiling frescoes depicting scenes from Genesis and his enormous Last Judgment *behind the altar.*

Between 1481 and 1483, Sixtus IV commissioned numerous artists to produce 14 fresco decorations, illustrating the lives of Moses and Christ, along the walls. Between 1508 and 1512, MICHELANGELO frescoed the barrel-vaulted ceiling for Pope Julius II with scenes illustrating the Book of Genesis, from the Creation to the Flood. The lunettes over the windows depict Christ's ancestors; figures of prophets and sibyls sit in illusionistic architectural niches surrounding the scenes. The pendentives illustrate Old Testament episodes. This network of images is unified through Michelangelo's masterful illusionism and unparalleled skills as a draftsman. Together with his *Last Judgment* (1536–41), painted for Paul III, these frescoes rank among the most famous and important paintings of the 16th century.

Over the years the frescoes were obscured by dirt and layers of varnish and glue applied at various times. In the 1980s the Michelangelo paintings were cleaned to reveal their original colors, despite protests from some art lovers who feared that cleaning would damage them.

Sisyphus [sis'-i-fuhs] In Greek mythology Sisyphus, the wily son of Aeolus and king of Corinth, outwitted even

Death. When Death came to fetch him, Sisyphus bound him in chains so that no one could die until Zeus freed him. When Death finally claimed him, Sisyphus was condemned eternally to roll a heavy stone to the top of a hill, only to have it fall back each time.

sitar [sit-ar'] One of the principal stringed instruments of India, the sitar is a form of LUTE with movable frets. It has 2 or 3 drone strings and 4 or 5 strings for melodic playing. In addition, from 11 to 19 wire strings beneath the frets are each tuned to a different pitch so that at least one will vibrate in sympathy with any pitch being played. There is a resonator gourd beneath the bridge area; another, affixed to the neck, serves only to support the instrument on the floor.

See also: INDIAN MUSIC.

Sitka [sit'-kuh] The city of Sitka (1990 pop., 8,588) lies in southeastern Alaska, on Baranof Island in the Alexander Archipelago. Fishing, canning, and lumbering are the main economic activities. Founded by Aleksandr Baranov in 1799, Sitka was the capital of Russian America and served until 1900 as capital of Alaska.

Sitting Bull Sitting Bull, or Tatanka Iyotake, 1831–90, was a great SIOUX leader of the Hunkpapa Lakota group who helped defeat Gen. George CUSTER at the Little Bighorn (see LITTLE BIGHORN, BATTLE OF THE).

Born on the Grand River in South Dakota, from his early adulthood Sitting Bull fought hostile tribes and white intruders on Sioux lands. He excelled in the virtues most admired by the Sioux: bravery, fortitude, generosity, and wisdom. With chiefs CRAZY HORSE and GALL, he stood fast against surrendering land or mining rights in the Black Hills after gold was discovered there in the mid-1870s. The three chiefs successfully attacked Custer at the Little Bighorn (1876), after which Sitting Bull and other Sioux fled to Canada. Returning in 1881, he was imprisoned for 2 years before going back to Standing Rock Reservation. Some observers have said that the reason he was allowed to travel with BUFFALO BILL and his Wild West Show, organized in 1883, was to keep Sitting Bull away from the reservation.

In 1890, shortly before the massacre of the Sioux at WOUNDED KNEE, Sitting Bull permitted Grand River people to join the antiwhite GHOST DANCE cult and was therefore arrested. In the fracas that followed he was killed by Indian police. His remains are buried near Mobridge, S.Dak. He is still revered at Standing Rock Reservation.

Sitting Bull, chief of the Hunkpapa Lakota (Sioux) tribe, led his people in the struggle against white encroachment on Sioux territory. His wisdom, courage, and powers of healing are legendary. He participated in the Battle of the Little Bighorn ("Custer's Last Stand") and in the Ghost Dance uprising.

Sitwell (family) A sister and two brothers in an aristocratic English family, the Sitwells attained distinction in literature—Edith Sitwell, b. Sept. 7, 1887, d. Dec. 9, 1964; Osbert Sitwell, b. Dec. 6, 1892, d. May 4, 1969; and Sacheverell Sitwell, b. Nov. 15, 1897, d. Oct. 1, 1988. At the forefront of the avant-garde movement of the 1920s, they provided an alternative to the Bloomsbury group in matters of taste in literature, art, and music.

Edith Sitwell, a fine poet, was innovative in her imagery and rhythm, aiming for the effects of music. She wrote a biography (1930) of Alexander Pope and a novel based on the life of Jonathan Swift, *I Live under a Black Sun* (1936). In collaboration with the composer Sir William Walton, she wrote the poems for the now popular *Facade*, an entertainment first publicly performed in 1923.

Osbert Sitwell, also a poet, is primarily remembered for his autobiography (1945–50) in five volumes, the first of which is *Left Hand, Right Hand!* His descriptive power, wit, and scholarship are also revealed in such works as the satirical novel *Before the Bombardment* (1927), the travel book *Winters of Content* (1932), and essays.

Sacheverell Sitwell, also a poet, was primarily a critic and essayist who wrote on art, music, travel, architecture, and many other subjects. His works include *Southern Baroque Art* (1924), *Liszt* (1934), *An Indian Summer* (1982), and the autobiographical *All Summer in a Day* (1926).

Six Nations see IROQUOIS LEAGUE

16th Amendment see CONSTITUTION OF THE UNITED STATES

6th Amendment see BILL OF RIGHTS; CONSTITUTION OF THE UNITED STATES

Sixtus IV, Pope [siks'-tuhs] Sixtus IV, b. July 21, 1414, d. Aug. 12, 1485, pope from 1471 to 1485, was one of the most important Renaissance pontiffs. A native of Celle, near Savona, he was originally named Francesco della Rovere. From impoverished origins, he rose to become (1464) minister-general of the Franciscans before he was elected pope. Sixtus took advantage of his position to engage in nepotism on a grand scale. He also became involved (1478) in the Pazzi conspiracy, an attempt to overthrow the MEDICI in Florence, which resulted in the murder of Giuliano de'Medici; instigated several wars among the Italian states; and engaged in a prolonged dispute with Louis XI of France. Sixtus IV was, however, an enlightened and generous patron of arts and letters; he built the Sistine Chapel and enlarged the Vatican Library and opened it to the public.

Sixtus V, Pope Sixtus V, b. Dec. 13, 1520, d. Aug. 27, 1590, was pope from 1585 to 1590. Born at Grottammare, near Montalto in the March of Ancona, he was originally named Felice Peretti. As a Franciscan he gained a reputation as a preacher, canon lawyer, and counselor (1557–60) to the Venetian Inquisition. His severity in the last position led to his removal. Although elected pope unanimously, Sixtus was a compromise candidate. He immediately set about his tasks with extraordinary vigor. His predecessor, Gregory XIII, had left him with lawless urban and rural populations, an empty treasury, and a flagging administration. Sixtus righted these situations so swiftly and effectively that he is reckoned as one of the ablest of all the popes, as well as one of the great figures of the COUNTER-REFORMATION.

Sjælland see ZEALAND

skaldic literature [skawl'-dik] Skaldic literature, from the old Norse *skáld*, meaning "poet," is that medieval Icelandic poetry which is not heroic or mythical (for the latter, see EDDA). It includes all the incidental verse found in the Icelandic SAGA, as well as the long laudatory poems—*drápur*—in honor of rulers. Skaldic poetry was composed in ornate meters, usually *dróttkvætt*, "court measure," or *hrynhent*, "accentuated verse," both of which have internal rhymes and consonances in alternate alliterative lines. The poetry is also strewn with kennings, or circumlocutions, such as "wound-bee" for arrow. The most accomplished skald was Egill Skallagrímsson (910–90).

Skanderbeg [skan'-dur-beg] Skanderbeg (or Scanderbeg), b. *c.*1404, d. Jan. 17, 1468, an Albanian national hero, led a revolt against Ottoman Turkish domination of Albania. Originally named George Kastrioti, he was given the name Iskander Bey (corrupted to Skanderbeg) while in Turkish service, up to 1443. Partially subsidized by Venice, Naples, and the papacy, Skanderbeg defeated 13 Turkish expeditions against him, and in 1461, after a 17-year struggle, the warring parties agreed on a 10-year truce. Skanderbeg, however, broke the truce in 1463, and after his death the Turks reconquered Albania.

skate Skates, family Rajidae, are cartilaginous fishes placed with RAYS, guitarfishes, and sawfishes in the order Batoidei. Batoides are grouped with sharks in the class Chondrichthyes. Skates, like rays, are flattened fishes with enlarged, winglike pectoral fins that are firmly joined to the head. Skates have five gill slits beneath the head and lack anal fins. The eyes are situated dorsally. The mouth and nostrils are situated ventrally, an adaptation to the bottom-feeding habits of most species. The teeth are molarlike and are used to crush prey such as crustaceans and mollusks. Skates usually have a reduced caudal fin and lack a spine at the base of the caudal peduncle (the "tail"). The American Pacific big skate, *Raja binoculata*, of the Pacific coast of North America, reaches 2.4 m (8 ft) in length, but most species are less than 0.9 m (3 ft). Females are larger than males.

Skates, like other chondrichthyans, have internal fertilization. The embryos are enclosed in an egg case secreted by the female. After the young hatch, empty egg cases may wash ashore, where people call them "mermaid's purses."

There are three recognized families of skates. The largest, Rajidae, contains the majority of species (about 110) and the most common genus, *Raja*. This group is distinguished by having two dorsal fins. The remaining two families contain few species and have one or no dorsal fin.

skateboarding Skateboarding—an offshoot of roller-skating, but closely related to both surfing and skiing in terms of balance, weight placement, and control of direction—is a U.S. phenomenon that developed from a fad into a sport.

Skateboards consist of three main parts: the board, called a deck; the axle assembly, or truck; and the four wheels. Skateboards are available in a wide variety of designs and materials. A skillful skateboarder is capable of performing tricks and creative movements, such as turning, spinning, traveling backward and forward, sitting, kneeling, balancing on one or two hands, and jumping over obstacles.

A skateboarder, or "skurfer," attempts a 180-degree turn in midair above a concrete course. Because of the high risk of injury involved in this popular sport, skateboard enthusiasts are encouraged to wear rigid headgear and padding to protect knees and elbows.

The American National Skateboard Association, a now-defunct nonprofit organization headquartered in San Bernardino, Calif., was created to standardize competitions and the criteria for judging contests and tournaments.

The original skateboards were merely wooden planks to which roller-skate wheels were attached. In the 1970s, however, Frank Nasworthy of California devised a truck with smooth-rolling urethane wheels, and skateboarding became highly popular.

skating see ICE SKATING; ROLLER-SKATING

skeletal system A skeleton is a structural framework that supports the body against gravity and also provides leverage for the action of muscles and the movement of the body's parts. All vertebrates (backboned animals; see CHORDATES) have skeletons built according to the same basic plan as the human skeleton. INVERTEBRATE animals may have skeletons, but never according to the vertebrate plan.

Invertebrate Skeletons

Earthworms. One of the simplest types of skeleton is the so-called hydrostatic skeleton found in earthworms and certain other invertebrates. Like an engineer's hydraulic system, this skeleton works by the application of a force to an incompressible, watery fluid. In the earthworm, the force is supplied by the contraction of longitudinal muscles. These muscles shorten the body segment, thus forcing the walls of the segment to bulge outward. This bulge anchors the worm in its burrow, providing leverage against which other segments can be pulled forward. The moving segments are made narrower by the contraction of circular muscles.

Arthropods. Arthropods, such as insects and crustaceans, possess an external skeleton (exoskeleton). This exoskeleton has evolved from the hydrostatic type of skeleton. It functions basically as a hardened hydrostatic skeleton with pairs of legs added. The legs are moved directly by muscles that span the individual joints. The wings of insects, however, are moved by a hydrostatic mechanism similar to that of the earthworm skeleton. The arthropod exoskeleton also functions as a skin; it consists of a layer of cells called the hypodermis. It is these cells that secrete the nonliving cuticle. The inner part of the cuticle (endocuticle) is the thickest and is composed of proteins and chitin. A hardened exocuticle lies above the endocuticle and is coated by a waxy epicuticle. The cuticle becomes rigid where calcium salts are present. Across joints, however, where flexibility is needed, the cuticle is not calcified and the exocuticle layer is absent.

Shells. Other invertebrates tend to have either more rigid skeletons, known as SHELLS, or else none at all. The hard outer shell of mollusks and brachiopods, composed largely of calcium carbonate, provides protection as well as support. In snails, the shell is all one piece, but clams and brachiopods have shells with two pieces that are hinged together. Rigid, immovable shells (tests) are found in many unicellular organisms such as foraminifera, and also in such colonial organisms as corals and bryozoans. The tiny algae called diatoms have shells composed of two overlapping plates.

Echinoderms. The external skeleton of starfish, sea urchins, and other echinoderms consists of a series of individual plates embedded within the skin.

Vertebrate Skeletal Tissues

The skeleton of vertebrates is largely internal and is known as an endoskeleton. Its most characteristic feature is the presence of a backbone made up of individual vertebrae.

The two major supportive tissues of the skeleton are BONE and CARTILAGE. Bone is stronger and easier to reshape because it has blood vessels running through it that replenish nutrients and oxygen, but cartilage grows faster; in fact, much of an embryonic skeleton consists of cartilage, which will later be replaced by bone. The sharklike fishes are called cartilaginous fishes because their skeletons consist solely of cartilage. In most other adult vertebrates, bone is predominant.

Bone is a living material containing many active bone cells (osteocytes). A typical bone contains many osteocytes, arranged in what are called Haversian systems, each of which contains a blood vessel running within a central Haversian canal. The bone material contains calcium salts (mainly calcium phosphate) and also a fibrous protein, collagen. These materials occur in cylindrical layers (lamellae) that are concentrically arranged in each Haversian system around the central canal. The strength of a bone is imparted by the orientation of these Haversian systems parallel to the direction of greatest stress. The osteocytes live in flattened spaces (lacunae) within the lamellae. Each osteocyte maintains contact with other osteocytes through a series of minute pores called canaliculi, which keep each osteocyte in contact with the blood vessel running through the Haversian canal.

Most bones are hollow and contain blood-forming marrow tissue within their cavities. Bones are connected to muscles by tendons and to one another by joints and ligaments, all of which are composed principally of the protein collagen.

Most bones are formed of cartilage tissue at first, the bone tissue gradually replacing the cartilage. The human skeleton reaches its final adult size at about 20 years of age in males, 18 years in females.

Vertebrate Skeletons and Their Organization

From the most primitive vertebrates on, the vertebrate skeleton has consisted of three distinct but unequal components: the dermal, the visceral, and the somatic skeletons. The dermal skeleton originally formed a shield of protective armor around the primitive vertebrates. These bones can be distinguished by their embryological development within membranes—they are never preceded by cartilage. The only human remnants of this dermal skeleton are the collarbone (clavicle) and certain bones of the skull.

The visceral skeleton includes those bones which have been preformed in cartilage and which originally supported the gill arches in fishes. The most primitive fishes were jawless, and all their gill arches were similar to one another. Jaws evolved when the first gill arch became modified as a food-seizing apparatus. The jaws of submammalian vertebrates are held together by such visceral elements; in mammals, however, these bones have migrated into the middle ear, where they form two of the three auditory ossicles. Human remnants of the visceral skeleton include the alisphenoid, the three auditory ossicles, and the hyoid apparatus.

The third and largest component of the vertebrate skeleton is the somatic skeleton, divided into axial and appendicular portions. The axial skeleton includes somatic bones of the skull, the vertebrae, the ribs, and the breastbone (sternum). The appendicular skeleton includes the limbs and their supports. The shoulder girdle (pectoral girdle) supports the forelimbs, and the pelvic girdle supports the hind limbs.

Rickets

The most common disease of the bones is rickets, a failure of the bone cells to deposit enough calcium salts to make the bones rigid. Severe rickets results in curvature of the limb bones and impairment of the ability to walk properly. Once a common childhood disease, rickets can be prevented by a diet rich in calcium and vitamin D.

skeleton, human The human skeletal system is composed of individual bones and cartilage that receive a supply of blood and are held together by fibrous connective tissue, ligaments, and tendons. The three main functions of the skeletal system are protection, motion, and support. The system protects the body by enclosing the vital organs; it permits locomotion by responding at certain joints to the contractile activities of skeletal muscles; and it supports the body by serving as a framework to which tendons and fascia are attached, enabling skeletal muscles, viscera, and skin to obtain a holdfast. It also serves as a depot for calcium, which is vital to proper functioning of cell membranes, and for phosphorus, which is needed in intermediary metabolism. In addition, the skeletal system is important because bone produces blood cells.

At birth the human body has about 275 bones, but as the body develops many of these bones fuse together. In the adult human the skeleton consists of 206 name-bearing bones and a variable number of largely unnamed sesamoid bones. Sesamoid bones develop in the capsules of certain joints or in tendons, which hold muscle to bone, where they provide special support or reduce friction. The best-known sesamoids are the patella (kneecap) and pisiform (wrist bone).

Classification of Bones

Bones may be classified as long, short, flat, irregular, or sesamoid. The long bones of the limbs consist of a central shaft (diaphysis) between two ends (epiphyses) that form joints with one or more other bones. The short bones, in the wrists and ankles, have a spongy core within a shell of compact bone. The flat bones include the ribs and many skull bones. They consist of two plates of compact bone with a spongy layer between. All the remaining named bones are irregular bones, except the patella, pisiform, and some foot bones.

Divisions of the Skeletal System

The skeleton is composed of an axial and an appendicular division. The axial division conprises the skull, spinal column, and thoracic cage. The appendicular division includes an upper extremity (shoulder girdle and its appendages) and a lower extremity (pelvic girdle and its appendages).

The Skull. The skull consists of the cranium, which houses the brain, and the face. The cranium is made up of eight cranial bones, including one frontal, two parietal, two temporal, one ethmoid, one occipital, and one sphenoid.

The frontal bone is the forehead. Its supraorbital margins provide a certain degree of protection to the eyes. Present within this bone is the frontal sinus, which opens into the nasal cavity. The paired parietal bones comprise the walls of the cranium, whereas the paired temporals form the sides and part of the base. Each temporal bone encloses an ear and forms a movable joint with the lower jaw.

The ethmoid bone lies mainly within the skull cavity, between the cranial and nasal cavities. A front view reveals a perpendicular septum, which separates the nostrils from one another. On each side of the ethmoid bone are ethmoid sinuses that drain into the nasal cavity.

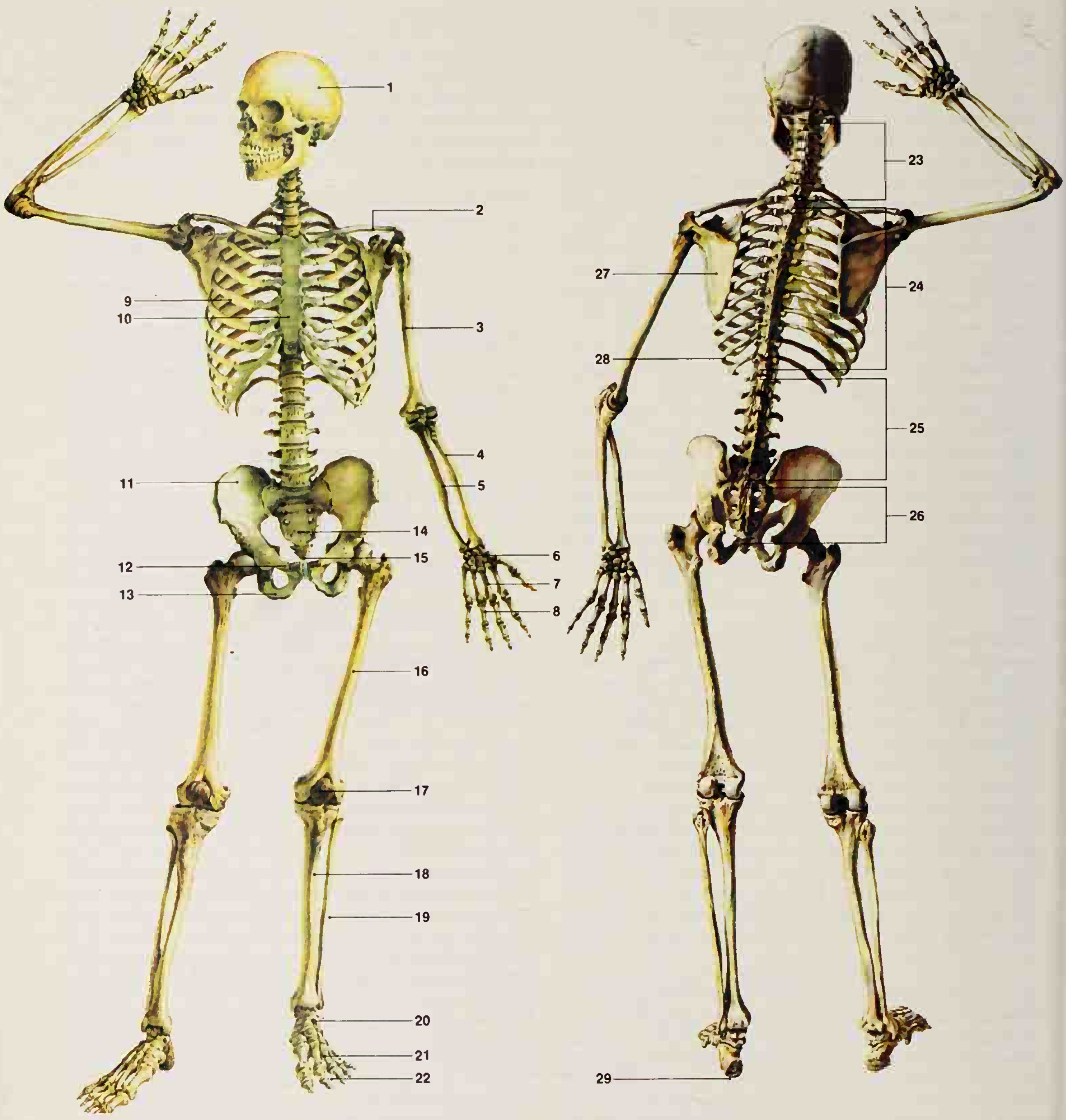
The occipital bone forms the floor and lower rear wall of the cranium. Its outstanding feature is the foramen magnum, a large hole through which the spinal cord passes into the brain. Adjacent to the foramen magnum are two protuberances, called occipital condyles, which articulate with the vertebral column and allow nodding of the head.

The sphenoid (sphinxlike) bone lies immediately in front of (anterior to) the temporal bones. A septum down the midline divides the sphenoid sinuses that drain into the nasal cavity. A large depression within what might be viewed as the ceiling of the sphenoid bone provides protection to the pituitary gland, which is immediately above it.

Present within each middle ear within the temporal bone are three ear bones (malleus, incus, and stapes), which transmit sound waves into the inner ear.

The Hyoid Bone. The hyoid (U-shaped) bone, located in the neck, is suspended by ligaments from processes that extend downward from the temporal bones. It acts as a point of attachment for most of the anterior muscles in the neck.

The Face. The face contains 14 facial bones. Seven are superficial and can be felt with the fingers, whereas the other seven are located deeply. The deep facial bones include two lacrimals, two palatines, one vomer, and two



The adult human skeleton contains 206 bones. Twenty-two of these are in the skull (1). *The arm structure includes the clavicle* (2), *humerus* (3), *radius* (4), *ulna* (5), *carpus* (6), *metacarpus* (7), *and phalanges* (8). *Chest organs are protected by the ribs* (9) *and sternum* (10). *The ilium* (11), *pubis* (12), *ischium* (13), *sacrum* (14), *and coccyx* (15) *make up the pelvic girdle. The leg structure includes the femur* (16), *patella* (17), *tibia* (18), *fibula* (19), *tarsus* (20), *metatarsus* (21), *and phalanges* (22). *Visible in back view* (right) *is the spine, consisting of the cervical* (23), *thoracic* (24), *lumbar* (25), *and sacral* (26) *vertebrae; the scapula* (27); *the floating ribs* (28), *which are not connected to the sternum; and the calcaneus* (29).

inferior conchae. The lacrimal bones form part of the median wall of each orbit (eyeball cavity). The palatine bones make up part of the lateral walls and floor of the nasal cavity, part of the roof of the mouth, the floor of the orbits, and the rear (posterior) portion of the hard palate. The vomer, which is flat, forms the rear (posterior) and basal portion of the nasal septum.

The superficial facial bones include two nasal, two zygomatic, two maxillary (upper jaw), and one mandibular (lower jaw). The nasal bones lie side by side, uppermost along the median line of the nose. They support the flexible cartilaginous inferior region of the nose. The zygomatic bones form the prominences of the cheek and part of the lateral and inferior walls of the orbits. The maxillary bones fuse medially to form the upper jaw, which contains sockets for embedding the teeth. The maxillary bones constitute the bulk of the hard palate in the roof of the mouth. They also form part of the walls of the orbital and nasal cavities and contain sinuses that drain into the nasal cavity.

The Spinal Column. The spinal column consists of 26 bony segments (vertebrae): 7 cervical (neck), 12 thoracic (chest), 5 lumbar (lower back), 1 sacral, and 1 coccygeal (tailbone). Each vertebra, except the first and last, has a so-called body. These bodies are aligned with one another and are separated from each other by an intervertebral disk.

The vertebral bodies function to bear weight. The disks, made of cartilage, cushion the vertebrae, lubricate the joints between vertebrae, and act as shock absorbers. A pair of stalks, called pedicels, arises laterally from each vertebral body. The pedicels of adjacent vertebrae are arranged to form openings through which the spinal nerves emerge.

All vertebrae except the coccyx also have an opening through which the spinal cord passes, and various processes that, together with their attached ligament and muscle, limit the kinds of movements the spine can make.

The Thoracic Cage. The thoracic cage is composed of 12 pairs of ribs, 12 thoracic vertebrae, and the sternum (breastbone). The first 7 pairs of ribs are called true ribs because they form a direct union with the sternum. Ribs 8 through 12 are called false ribs. Of these, the first 3 pairs are not attached to the sternum but unite with each other and with rib 7; ribs 11 and 12 are called floating ribs because they have no anterior attachment.

The Shoulder Girdle. The shoulder girdle consists of two scapulae (shoulder blades) and two clavicles (collarbones). The entire apparatus, together with its musculature, permits such functions as raising the hands skyward.

The Upper Paired Appendages. Each of the upper paired appendages consists of an arm, forearm, and hand. The arm contains a single bone, called a humerus. The head of the humerus forms a ball-and-socket joint with the scapula.

The forearm contains 2 bones, a radius and an ulna. The hand contains 8 carpals, 5 metacarpals, and 14 phalanges. The carpals constitute the wrist. The metacarpals form the palm. Distal to the metacarpals are the phalanges, 2 for the thumb and 3 for each finger.

The Pelvic Girdle. The pelvic girdle supports the trunk on the thighs while standing, permits sitting, and provides protection to the urinary bladder, ovaries, oviducts and uterus, and rectum. It is formed from two hipbones; a sacrum, which lies between the hipbones; and a coccyx. Each hipbone consists of an ilium, ischium, and pubis, which are ossified in adults. The pubis forms the front (anterior) region of the hipbone, where the two hipbones unite by way of a cartilaginous bridge. Where the three components of each hipbone unite, a socket is formed, which receives the head of the femur.

The Lower Paired Appendages. Each lower paired appendage is composed of a thigh, leg, and foot. The thigh is built upon the femur, a large, heavy bone that connects the hipbone to the tibia of the leg. The joint between the femur and tibia is provided with some protection by the patella (kneecap), which is embedded in the tendon of the large thigh muscles.

In addition to a tibia, the leg contains a fibula. Whereas the tibia (shinbone) serves to bear weight, the fibula facilitates certain movements at the ankle, which is the joint between the tibia, the fibula, and one of the tarsal bones, the talus.

The foot contains 7 tarsal bones, 5 metatarsals, and 14 phalanges. Together with surrounding tissues, these bones form a longitudinal arch from heel to toes and a metatarsal arch from side to side.

Skelton, John Honored by Oxford and Cambridge as poet laureate, John Skelton, b. *c.*1460, d. June 21, 1529, became court poet to Henry VII and later was named royal orator by Henry VIII. Having become a priest in 1498, Skelton went to Diss, Norfolk, in 1503 as resident rector; nine years later he returned to London, where he died.

As courtier and cleric, Skelton attacked secular and religious abuses through one play, *Magnyfycence* (1516), and many satiric poems, including the *Bowge of Courte* (1498), *Collyn Clout* (1521), and *Why Come Ye Nat to Courte?* (1522). His lasting verse, exemplified by *Phyllyp Sparrowe* (*c.*1505) and *The Tunnyng of Elynour Rummyng* (1517), was written in what has come to be called Skeltonics: short lines of colloquial English with varied numbers of syllables but two strong beats, end-rhymed in couplets, triplets, and sometimes quadruplets.

skepticism *Skepticism* (from the Greek, *skeptesthai*, "to examine" or "to consider") is a general name for the philosophic or scientific attitude that rejects claims to certainty. Its basic philosophical contention is that the possibility of knowledge is limited by the limitations of the mind itself or by the inaccessibility of the object. DEMOCRITUS is generally regarded as the first skeptic; he called the senses into question as a guide to objective reality. During the Hellenic period the Greek SOPHISTS were skeptical of any claims to found ethics on natural rights or objective values. During the classical period PLATO'S

Academy developed skepticism as its official school position. This transformation of Plato's thought seems to have come about through an agreement with the need to grasp the Platonic Forms for any kind of certainty, combined with a disagreement as to whether human intelligence can ever attain such a grasp. This Academic view became well known in the West through the writings of CICERO.

Other skeptics during the classical period include PYRRHO OF ELIS, his follower Timon of Athens (*c.*320–230 BC), and, later in Rome, Sextus Empiricus (AD *c.*200). GORGIAS, the Sophist, in his speech "On the Nature of Things," had first defended skepticism by collecting disagreements among the experts in science and philosophy. Sextus Empiricus developed a similar technique: he showed that the "criterion," the test of certainty advocated by one school, contradicted the certainty of the doctrines of the other schools, each of which had an alternative "criterion."

During the modern period Michel de MONTAIGNE expressed doubt about transcultural absolute norms much as the urbane Greek Sophists had. René DESCARTES used "systematic doubt" as a main tool of his method. David HUME, in his *Dialogues on Natural Religion* (1779), offered a tentative dialogue in the manner and spirit of Cicero; in his *Treatise of Human Nature* (1739–40) and other works he set the tone for contemporary discussion.

One difficulty faced by the skeptic, and one his opponents have never hesitated to point out, is that his claim to absolute uncertainty and doubt sounds just as dogmatic and just as certain as the doctrines of the so-called dogmatists he is criticizing.

Skidmore College Established in 1903, Skidmore College is a private 4-year liberal arts school for men and women in Saratoga Springs, N.Y. The college has a nursing program and is particularly noted for its instruction in the liberal arts.

skiing Skiing, the practice of sliding over snow on runners attached to each foot, has evolved into a sport with two distinct but overlapping branches. Nordic skiing consists of cross-country travel, with the skier providing propulsion over moderately undulating terrain and jumping off prepared jumping hills. Alpine skiing, an adaptation of Nordic skiing to the relatively steep and frequently bumpy slopes of the European Alps, is primarily downhill skiing, with the skier usually returning to the top of the mountain by lift.

The fundamentals of the two branches are similar, but their physical and technical demands differ, and each has its own specialized equipment. Alpine skis, boots, bindings, and poles are designed to give the skier stability and quick, precise control over the almost continuous turns that must be made to keep speed in check. For cross-country, the equipment is made to allow the skier to stride without straining and is as light as possible in order to reduce fatigue over long distances. For jumping, the skis are wide and long in order to provide strength and aerodynamic lift.

Recreational and Competitive Skiing

Substantial differences exist between recreational and competitive skiing. A recreational skier may ski at will, limited only by the terrain and snow conditions. In competitive Alpine skiing, the racers are required to follow a course marked by a series of gates that are made of two tall poles set at varying distances apart, depending on which of the three Alpine events is involved. Downhill is an all-out speed event—average speeds of more than 80 km/h (50 mph) are common—with only enough gates to keep the racers on the designated course and away from dangerous obstacles. Slalom is a test of turning ability in which a racer moves through a series of narrow, closely spaced gates. Giant slalom involves elements of both downhill and normal slalom; the gates are wider and further apart than in the latter, and speeds are higher.

At the 1992 Winter Olympics, in Albertville, France, Donna Weinbrecht of the United States (left) *won the first gold medal in the new Olympic sport of freestyle skiing.* (Center) *Toni Niemenen, Finland's 16-year-old ski-jumping sensation, jumped to gold medals in the team and large hill events. He holds his skis in the new V-shaped position rather than parallel while airborne; this gives jumpers greater lift, allowing them to jump farther.* (Right) *Italy's Alberto Tomba repeated his 1988 Calgary Olympic success with a gold medal in the giant slalom.*

In cross-country competition, the standard distances for men are 10 km (6.2 mi), 30 km (18.6 mi), and 50 km (31 mi) in the individual events and a 4 × 10-km relay; women ski 5-km (3.1-mi), 15-km (9.3-mi), and 30-km distances, and a 4 × 5-km relay. There are two jumping competitions (for men only), one on hills where the average jump distance is about 70 m (76.6 yd), another with an average distance of about 90 m (98.4 yd). In addition, there is ski flying, which is conducted under slightly different rules, in which jumps of 176 m (192.4 yd) have been recorded. Other Nordic competitions are Nordic Combined, in which points earned in 70-m jumping and a 15-km cross-country race are added to determine the results, and the BIATHLON, which combines cross-country and target shooting.

Competitive skiing opportunities are available at all levels of ability and age. For serious racers and jumpers, state, regional, and national events exist for three major age groups—junior, senior, and veteran—under the auspices of the U.S. Ski Association. The best racers are selected for the U.S. Ski Team, which competes annually in an international series called the World Cup circuit and, every two years, in either the Olympic Winter Games or the World Championships. A professional tour is also held in the United States.

History

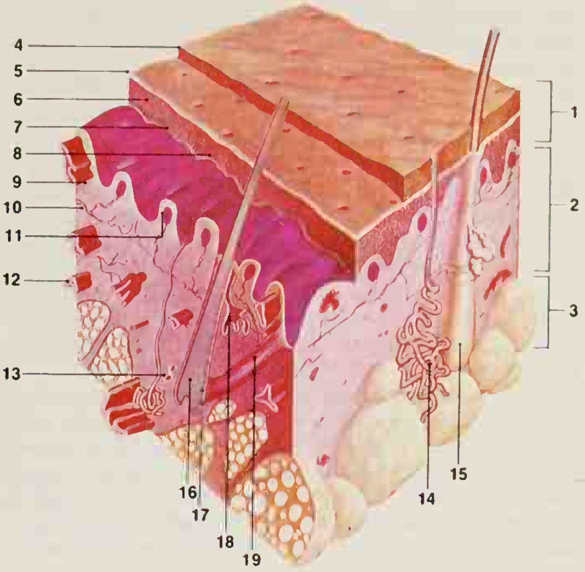
Remnants of skis found in Norway and Sweden date from more than 4,000 years ago. Skiing began to assume its modern form in the mid-19th century, when the Norwegians developed bindings that greatly improved control over the skis and made it possible to jump and turn. The Nordic events as they are known today date from this period. Reports of the use of skis in late-19th-century Norwegian Arctic expeditions spread word of the sport and inspired mountaineers to introduce it into the Alps. Because of the steep slopes and deep snow there, the emphasis increasingly was put on the downhill run. This led to the development of competitive skiing.

Although Norwegian immigrants brought skiing to the United States about 1850, the sport did not gain popularity until the 1930s, following the installation of the first rope tow, in Woodstock, Vt., in 1934. About 600 U.S. ski areas are now in operation, and millions of Americans ski. Many of these areas feature cross-country as well.

Skiing has been an Olympic Games event since 1924.

skimmer Skimmer is the common name for the water birds comprising the family Rynchopidae. Skimmers are 36–50 cm (14.5–20 in) in length and use their long, lower mandibles to skim the surface for food while flying low over water on long, narrow wings. The black skimmer, *Rynchops nigra*, is the American species.

skin In vertebrate animals the skin is the body's largest organ. It is the interface between the body's internal structures and the environment, serving as a protective coat against mechanical injury. It also plays a vital role in BODY TEMPERATURE regulation, sensory perception, and some immunological responses.



Human skin consists of two strata, the epidermis (1) *and the dermis* (2), *supported by a layer of fat* (3). *The epidermis is made up of several layers. Its outer layer* (4) *contains scalelike dead cells that are continuously shed. Granular cells in the next layer* (5) *produce a hard protein called keratin, which forms hair and nails. The third layer* (6) *consists of flattened polygonal cells. Below this is a deep layer of columnar cells* (7), *among which are found the melanocytes* (8)*—cells that produce the pigment melanin. The dermis consists of collagen and elastin, fibrous proteins that form connective tissue* (9). *In this tissue are embedded nerve fibers* (10), *sensory nerve endings* (11), *capillaries* (12), *lymph vessels* (13), *sweat glands* (14), *and hair follicles* (15). *Each follicle bears a hair shaft* (16) *in a sheath* (17); *an oil gland* (18), *which lubricates the shaft; and an arrector pili muscle* (19), *which tightens in response to fear or chill.*

The skin consists of a thin outer layer, the epidermis, and a much thicker inner layer, the dermis. Beneath the dermis is a layer of lobes of fat bound together by fibers extending down from the dermis. Between the epidermis and dermis is the basement membrane, to which both layers are attached.

Epidermis. The innermost cells of the epidermis, called basal cells, have fibers fixed to intracellular structures, called desmosomes, that link the cells together. The basal cells divide rapidly, forcing daughter cells toward the skin surface. Basal cells also synthesize keratin, a protein found in hair and nails; synthesis continues in the daughter cells, so that keratin fills the cells near the surface. As dead surface cells are shed, they are replaced from below.

Although outer epidermal cells absorb water readily, the deeper cells are watertight. The treelike melanocyte cells in the deeper epidermis produce a dark brown pigment called melanin (see PIGMENT, SKIN). The pigment is introduced into nearby cells through the "branch tips" of the melanocyte cells, in units called melanosomes. A third type of epithelial cell, the Langerhans cell, functions in immune responses of the skin. The epidermis lacks blood vessels and obtains its nutrition from capillaries in the dermis. It is well supplied by nerve endings that branch between the epidermal cells.

Dermis. The strength of the skin is due to the fibrous dermis. An outer layer beneath the basement membrane consists of tiny "hillocks" called papillae. They contain fine COLLAGEN fibers and are well supplied with blood vessels, nerves, and lymphatic structures. Beneath this layer is a far thicker one containing larger bundles of collagen fibers running in several directions. The fibers, synthesized by fibroblasts, are made of cross-linked collagen and are strong and resistant to enzymatic attack. This layer also contains elastic fibers, blood vessels, nerves, and lymphatic structures as well as specialized nerve endings and the various skin appendages, including hair, sweat and oil glands, and nails (see HOOF, NAIL, AND CLAW).

Hair. Except for the palms, soles, lips, eyelids, nipples, and parts of external genitalia, the mammalian body is usually covered with HAIR. In humans the hair is often thin and short and not readily seen on much of the body. Hair follicles are lined by epidermal cells. They form by a dimpling of the epidermis into the dermis. As the cells fill with keratin, they adhere to one another and form hair, which elongates as new cells form at the hair base. Melanosomes find their way into the hair cells, giving them color. From the wall of the follicle an oil gland provides a protective hair coating. Plugged oil glands form blackheads, and if these become infected they produce ACNE. Cold or fear can stimulate the tiny muscle attached to each hair follicle to erect the hair.

Sweat Glands. Human skin contains very many sweat glands, which secrete a watery fluid. These glands are especially numerous in hairless regions such as the palms and soles. Their ducts also form from dimples, lined with epidermal cells, that descend into the dermis and connect with gland cells. They are well supplied with nerves and respond to excessive heat by the secretion of sweat, whose evaporation cools the skin. This in turn cools the capillary blood in the dermis. Stimulation by the parasympathetic nervous system also causes secretion—the "cold sweat" of emotion.

The so-called apocrine sweat glands found in the armpits and the pubic region are attached to hair follicles and secrete an odorless milky fluid. Bacterial action on this fluid produces the distinctive body odor of an animal. The mammary glands, or BREASTS, are large, modified apocrine glands.

Skin Functions. The skin protects against mechanical injury and attack by bacteria, fungi, viruses, and parasites; its melanin blocks ultraviolet radiation. The skin controls body temperature in several ways, as well. Variable amounts of heat are lost through the skin by transfer from the dermis capillaries to the cooler epidermal cells, the amounts dependent on constriction or dilation of the dermal blood cells. Sweating cools the epidermis by evaporation.

The five distinct sensations arising from stimulation of skin nerves include touch, pain, heat, cold, and pressure (see SENSES AND SENSATION). Other skin sensations, such as vibration, are composites of these basic sensations.

The skin responds to challenges to the immune system (see IMMUNITY), as various ALLERGY reactions show. Certain dermal cells release chemicals that cause changes in capillary diameter (redness and warmth) and permeability (swelling), and stimulation of nerve endings (pain)—all signs of inflammation.

skin diseases The skin is subject to many disorders. They occur through the direct action of external agents or as symptoms of disease in other parts of the body. Susceptibility to skin disorders is modified and sometimes determined by genetic factors.

Lesions. The appearance of abnormal changes, or lesions, in the skin is an important element in diagnosis and treatment. Various lesions can occur, not all of them disease related. A flat lesion of a color differing from surrounding skin is called a FRECKLE. A papule is a solid, elevated but superficial mass, such as a raised MOLE or a WART. A wheal is a transitory lesion resulting from an allergic response, such as to an insect bite (see ALLERGY; HIVES). A nodule is a solid mass that extends deeper, such as in certain TUMORS and cysts. A vesicle is a tiny blister filled with clear fluid, such as in early chicken pox. A bulla is a large blister, most often seen as the result of a BURN. A pustule is an elevated skin area containing pus, as in the later chicken pox lesion. PURPURA is a skin discoloration caused by deposits of blood or blood pigments within the skin.

The appearance of such lesions may be modified by secondary changes. These include scales or flakes of dead skin, as seen in PSORIASIS and DANDRUFF; crusts, typically dried masses of material that have oozed out, as in impetigo; fissures, or sharp breaks, as seen in athlete's foot (see RINGWORM); ULCERS, or destruction of one or more skin layers, exposing underlying tissue; SCARS, resulting from newly formed CONNECTIVE TISSUE replacing lost tissue; and lichinification, a thickened scaly area in which normal skin creases and lines are exaggerated. Lesions may be seen in several different diseases, any one of which may have several different lesions.

Malignant Tumors. Any metastasizing tumor from elsewhere in the body (see CANCER) may appear in the skin. Many malignant tumors also originate in the skin. Four should be mentioned. Basal cell carcinoma may originate from basal cells of the epidermis. It almost never metastasizes, and it is easily cured. Squamous cell carcinoma does metastasize. Both tumors are common, especially in the elderly and in those overexposed to the Sun. Malignant melanoma derives from the same embryonic nervous tissue that produces moles. It appears to be more common in those overexposed to the Sun in childhood, and it metastasizes early and widely. Finally, the once-rare tumor called Kaposi's sarcoma has become more frequent because of AIDS (see AIDS).

Disorders Caused by Chemical or Physical Agents. Skin diseases that result from chemical and physical agents as well as infectious organisms include contact dermatitis, sunburn, heat rash, and bunions, corns, and calluses. Contact DERMATITIS is characterized by itching and burning sensations and reddening, blistering, "weeping," and crusting of areas of the skin. It is an acute or chronic skin inflammation caused by skin contact with irritants such as chemicals or poison ivy or with substances to which an individual is allergic, although the causes of the form of dermatitis known as ECZEMA are often unclear. Ultraviolet light causes erythema solare, or sunburn, signs of which can vary from simple reddening to blistering. The symptoms can range from pain in the skin to gastrointestinal disorders, malaise, and prostration. Miliaria (heat rash or prickly heat) is frequently seen in infants and obese adults. It is characterized by burning and itching and the aggregation of small blisters on covered areas during hot, humid weather.

Bunions, corns, and calluses on the feet or toes result from pressure and friction due to body deformities or from poorly fitting shoes. (See FOOT DISORDERS.)

When the skin is exposed to heat, electricity, radiation, or chemicals, it may also suffer a burn. Depending on the severity of the burn—that is, the depth of the skin layers destroyed and the area affected—a skin graft may be required (see PLASTIC SURGERY and TRANSPLANTATION, ORGAN).

Disorders Caused by Infections. ACNE, or acne vulgaris, the most common skin disease, is a skin condition thought to be secondary to hormonal changes of adolescence. Folliculitis, on the other hand, is caused by infection of hair follicles by staphylococci. The condition is sometimes called barber's itch, because individuals with beards tend to have deeper hair follicles that are more likely to be affected by bacteria. Furuncles (BOILS) and carbuncles are deeper and more serious infections of hair follicles, resulting in abscess formation.

Streptococcal pyoderma, or impetigo, and erysipelas are contagious infections caused by the entry of certain strains of streptococcal bacteria into breaks in the skin. Streptococcal pyoderma is characterized by the formation of localized crusty lesions. Erysipelatous lesions are usually widely spreading zones of redness, swelling, and blistering in the skin. Erysipelas is accompanied by systemic effects, including chills and fever; certain forms can rapidly involve large areas of the skin and can cause prostration and death.

Ringworm of the scalp (tinea capitis), of the body (tinea corporis), and of the groin (tinea cruris, or "jock itch") are fungal infections of the skin. The term *ringworm* arises from the circular form of the lesions. Dermatophytosis of the foot, or "athlete's foot," is also caused by a fungus. Fungal infections are often accompanied by itching, burning, stinging, and seepage of tissue fluids at the site of infection.

Scabies and pediculosis are common parasitic infections. Scabies is caused by mites that burrow into the skin. The mites' excretion of waste products into the skin causes intense itching, especially at night. Adults often acquire scabies by sleeping with or having sexual relations with an infected person. Pediculosis is a louse infestation of the scalp, trunk, or pubic area ("crabs"). Each of the three kinds is caused by a different species of louse. (See also VENEREAL DISEASE.)

The most common viral infections of skin are HERPES simplex (cold sore or fever sore) and herpes zoster (SHINGLES). Warts are another form of viral infection. Several types of warts occur on different parts of the body, each one caused by a particular type of virus (see PAPILLOMA).

skin diving Skin diving is a recreational, educational, or commercial underwater activity of ancient origin in which a diver swims freely—unencumbered by lines or air hoses—and without an external air supply (as opposed to SCUBA DIVING or deep-sea DIVING). Recreational or educational divers use a face mask for vision, webbed rubber fins for propulsion, a J-shaped plastic tube called a snorkel for breathing just below the water's surface, and, in many cases, a wet suit to negate the loss of body heat that would otherwise occur underwater. Although the use of mask, snorkel, and fins is ostensibly simple, it is suggested that at least one lesson be taken initially to learn such techniques as the clearing of the snorkel or mask of water and the proper fin kicks.

Commercial skin divers, most often pearl divers, commonly descend to depths of 30 m (100 ft) or even more wearing a mask and fins. Sponge diving is another type of commercial skin diving, and participants in this activity descend to depths as great as those of pearl divers; Greece, Italy, and the Florida Keys are important locations.

These skin divers are exploring Caribbean waters off the coast of Honduras. Breathing with a snorkel, a diver can view ocean life near the surface for as long as it is comfortable. In this instance, the warm tropical sea obviates the need for a wet suit.

skin graft see PLASTIC SURGERY

skink The skinks (family Scincidae), with about 75 genera and 600 species, are one of the two largest lizard families. They are widespread and are particularly abundant in the great forests of Africa and Indo-Australia. Typically, skinks have smooth, shiny, overlapping scales and elongate, cylindrical bodies. Their heads are cone shaped. Femoral pores are absent. The pupil is round, and many species have a large, transparent scale on the lower eyelid that enables them to see even when the lid is closed. In most species the tapering tail is easily broken but can be regenerated. Skinks are generally alert and active diurnal lizards but tend to be secretive, spending much time foraging under leaf litter.

In more than half of the scincid genera, limbs are degenerate. Burrowing forms also tend to have a reduction or fusion of the head plates, advantageous in making the skull more rigid for pushing through the substrate. Most skinks are small, usually not exceeding 20 cm (8 in) in total length, but a few species are larger, and the Solomon Islands giant skink, *Corucia zebrata,* may exceed 60 cm (24 in). This species is unusual in that it is arboreal and has a prehensile tail. Skinks are most frequently striped but may be banded, spotted, or uniformly colored. Males of many species develop broad heads, presumably used in fighting during the breeding season.

Most skinks feed primarily on insects and other arthropods, but some of the larger forms are partially or completely herbivorous. Skinks may be either oviparous or viviparous.

Skinks are divided into 4 subfamilies. The Acontinae consists of 3 viviparous South African genera that are limbless, burrowing forms. The Felinae is composed of 2 viviparous central African genera that have reduced eyes and ear openings covered with skin. The Lygosominae contains nearly 40 genera and is represented on all tropical and temperate continents. Members may be limbless or not and either viviparous or oviparous. The Scincinae has more than 20 genera that are found mainly in Africa. As with the Lygosominae, much variation exists in the condition of the limbs and mode of reproduction. Only 3 genera and 15 species of skinks exist in the United States: the ground skink, *Lygosoma laterale*; the sand skink, *Neoseps reynoldsi*; and the common skinks (genus *Eumeces*).

Skinner, B. F. Psychologist Burrhus Frederick Skinner, b. Susquehanna, Pa., Mar. 20, 1904, d. Aug. 18, 1990, is known for his studies of learning and for his advocacy of radical BEHAVIORISM. Skinner's early work, primarily done with rats, established him both as an excellent experimentalist and as more extreme in his opposition to models of internal processes than the predominant learning theorists (see LEARNING THEORY). His first major book, *The Behavior of Organisms* (1938), established a view from which he did not deviate in his long working career.

B. F. Skinner, an American psychologist, has been a great influence on the school of behaviorism, which attempts to explain and control behavior by reinforcement of reactions to controlled stimuli. His research and controversial publications have had a powerful impact on teaching methods and learning theory.

Skinner's innovative laboratory experiments, conducted with equipment of his own design, such as the SKINNER BOX, set lasting standards for rigorous objective observation in psychology. Unlike most behaviorists, who created theories about the connection between stimuli and reponses, Skinner studied the bond between operant (spontaneous) responses and the various possible patterns of subsequent reward. He took this operant conditioning to be a model of adaptive behavior.

Skinner's findings about the effectiveness of different schedules of reinforcement provided the rationale for the development of TEACHING MACHINES and programmed learning in the field of education and of BEHAVIOR MODIFICATION therapies. He applied these principles to social theory in his second book, *Walden Two* (1948).

The methodological position developed by Skinner opposed not only the learning theorists' models of internal stimulus-response connections but also speculation about biological causes of behavior, the use of introspective data, and the later development of internal models based on computer programs.

Skinner's work outlived that of the learning theorists, but in later years it looked increasingly limited. The noted linguist Noam CHOMSKY attacked Skinner's account of language as not only failing to explain the significant aspects of language but as circular and hence meaningless. HUMANISTIC PSYCHOLOGY considered his view that choices are determined by reinforcement schedules to be overly mechanistic and simplistic. COGNITIVE PSYCHOLOGY provided explanatory accounts of internal processes that researchers found persuasive. Studies of the BRAIN also produced explanations of behavior patterns that many found enlightening. In the face of these developments, Skinner remained a strict behaviorist.

His operant-conditioning methods, however, made a significant contribution to the development of learning models for the mentally retarded (see MENTAL RETARDATION) and for the treatment of addictive behaviors and PHOBIAS.

Skinner, Cornelia Otis An American writer and actress whose father was the noted actor Otis Skinner, Cornelia Otis Skinner, b. Chicago, May 30, 1901, d. July 9, 1979, wrote light verse, humorous essays, and stage monologues that she frequently performed herself. In collaboration with Emily Kimbrough she wrote the best-selling *Our Hearts Were Young and Gay* (1942), an amusing account of their youthful European travels in the early 1920s. With Samuel Taylor she wrote the popular comedy *The Pleasure of His Company* (1958), in which she also acted. Her other books include a biography of Sarah Bernhardt, *Madam Sarah* (1967), and *Life with Lindsay and Crouse* (1976).

Skinner box The Skinner box, named for its inventor, B. F. SKINNER, is an apparatus for the operant conditioning of small animals, such as rats or birds. The box measures about 30.5 cm (12 in) on a side. It is programmed to present its inmate with food as a reward for pressing a lever in the box. The program may be arranged to vary the frequency and type of reward.

skittles Skittles is a bowling game, played mostly in England, for as few as 2 or as many as 20 players divided into two teams, played with wooden pins (skittles) and a wooden or rubber ball, or a disk of hard wood, weighing 10–14 lb (4.5–6.35 kg), called a cheese. The skittles stand 1 ft (30.5 cm) high and weigh 7–9 lb (3.2–4 kg). The alley is 3 ft (91 cm) wide and 21 ft (6.4 m) long from the foul line to the first skittle. Each player has a turn—called a chalk—of three throws at the nine pins, which are arranged in a diamond pattern. A point is scored for each skittle knocked down. If all the skittles are downed on the first throw, the player scores 9 and throws at all the pins again. If all 9 are downed in two throws, the player scores 9 and the skittles are set up again for the third throw. When each player has completed three chalks, the side with the highest score wins that "leg," and a match is won by winning five legs.

Table skittles is played with miniature pins and a small ball that swings on a string suspended from a mast.

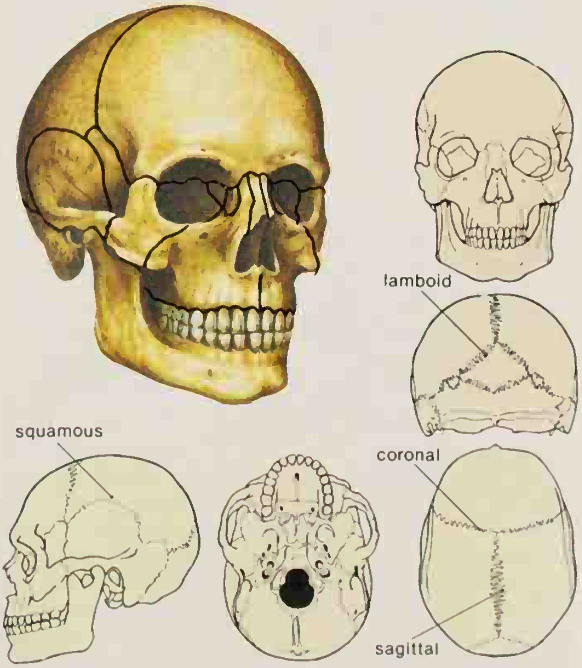
Skopje [skawp'-yah] Skopje, the capital of the republic of Macedonia in southern Yugoslavia and the third largest city in the country, lies on a major north-south route of the Balkans, about 320 km (200 mi) south of Belgrade. The population is 444,900 (1987 est.). A trading center for the surrounding agricultural region, the city manufactures iron and steel, electrical machinery, chemicals, textiles, carpets, and foodstuffs. Landmarks include a 12th-century monastery, a medieval Turkish inn, and several mosques. Cultural institutions include a university (1949) and several museums and concert halls.

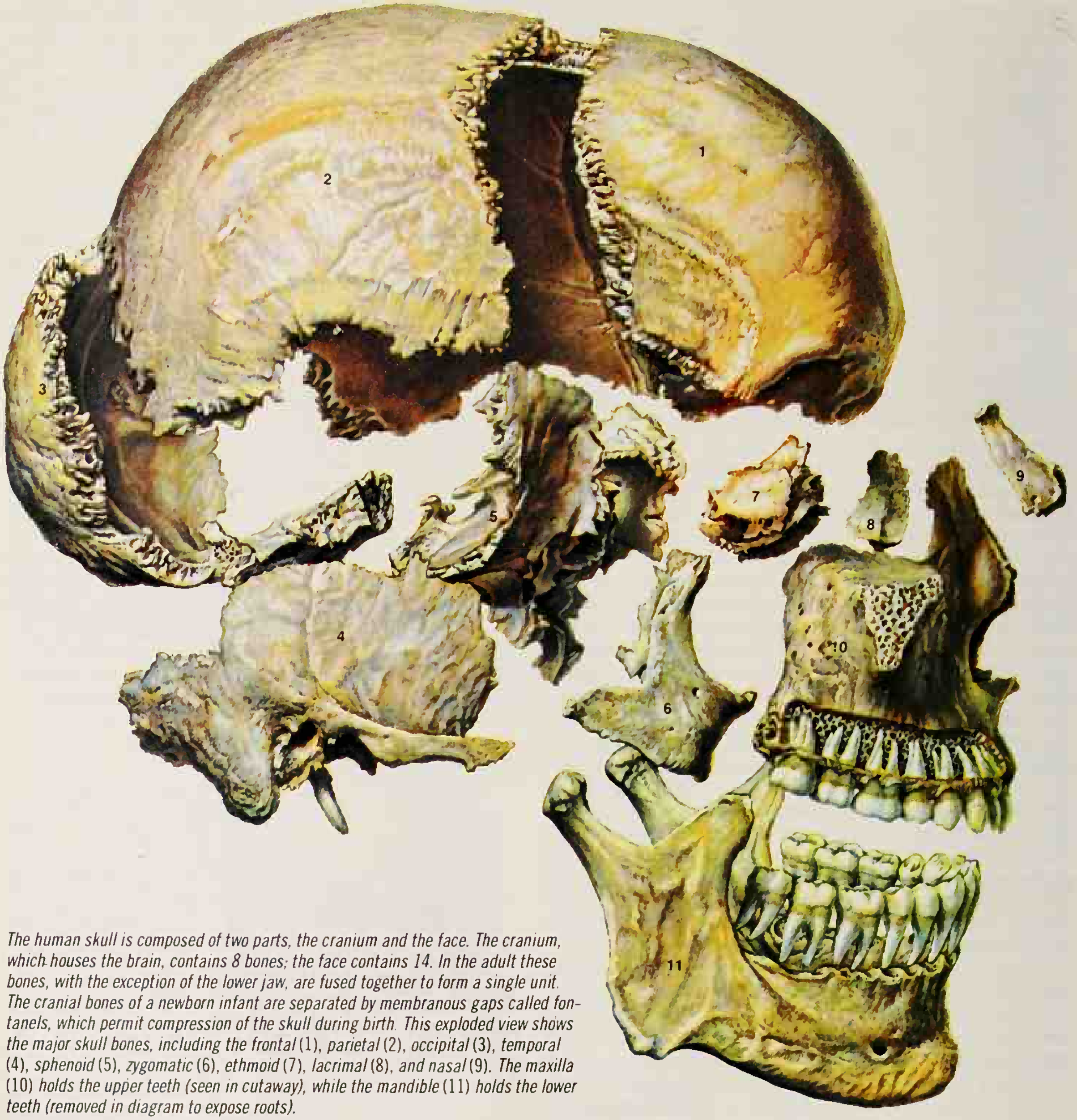
An ancient Illyrian city, Skopje became a Roman post called Scupi in the 4th century AD. It was taken by the Serbs in 1189 and by Ottoman Turks in 1392. A rail line between Belgrade and Greece contributed to Skopje's development in the 19th century. In 1913, during the Balkan Wars, the city came under Serbian control, and in 1918 it became part of Yugoslavia. An earthquake in 1963 destroyed more than half of Skopje, but the city has since been rebuilt.

skull The skull, part of the skeleton, houses and protects the brain and the major sense organs. Important features include the nasal passages, containing the turbinals, which are delicate scrolls of paper-thin bone; the orbits, or eye sockets; the teeth-bearing maxilla, or upper jaw, and mandible, or lower jaw; the zygomatic arches, or cheekbones; the auditory bulla (in mammals), housing the bones of the middle ear; the foramen magnum, a large opening through which the brain connects with the spinal cord; and many minute passages for nerves and blood vessels.

The deep skull bones that develop from cartilage are known as endochondral bones; the superficial bones, in-

The face contains seven deep bones and seven superficial bones. With the cranium bones, they house the sense organs, brain, and spinal cord. The lower jaw is attached to the cranium by a hinge; all other major skull bones are fused together by immovable joints called sutures. Views of the skull include (clockwise from top right): *front view; back view (lambdoid suture); top view (coronal and sagittal sutures); base of the skull, showing the opening for the spinal cord; and side view (squamous suture).*





The human skull is composed of two parts, the cranium and the face. The cranium, which houses the brain, contains 8 bones; the face contains 14. In the adult these bones, with the exception of the lower jaw, are fused together to form a single unit. The cranial bones of a newborn infant are separated by membranous gaps called fontanels, which permit compression of the skull during birth. This exploded view shows the major skull bones, including the frontal (1), *parietal* (2), *occipital* (3), *temporal* (4), *sphenoid* (5), *zygomatic* (6), *ethmoid* (7), *lacrimal* (8), *and nasal* (9). *The maxilla* (10) *holds the upper teeth (seen in cutaway), while the mandible* (11) *holds the lower teeth (removed in diagram to expose roots).*

cluding those of the face, develop directly from connective-tissue membranes and are called dermal bones, or membrane bones. Most human skull bones are united, often across a wavy suture, by connective fibrous tissue; a few are united by cartilage. Primitive land vertebrates had more than 50 paired skull bones; only 26 of these bones persist in humans and other mammals. In adult humans the braincase has a capacity of about 1,400 cm^3 (85 in^3) of soft tissue.

skunk Skunks, often mistakenly called polecats, are Western Hemisphere mammals of the WEASEL family, Mustelidae, order Carnivora. They are well known for the repulsive-smelling spray they eject from two anal glands at the base of the tail when disturbed. Skunks have black-and-white striped or spotted fur, which is prized in commerce. The striped, or common, skunk, *Mephitis mephitis,* ranges from 28 to 36 cm (11 to 15 in) in length, with

The striped skunk has powerful anal glands that emit a foul-smelling scent. When threatened, it turns its back, raises its tail as a warning, and then sprays the attacker.

a 43-cm (17-in) tail, and weighs from 0.75 to 2.5 kg (1.5 to 5.5 lb). Its habitat extends from southern Canada to northern Mexico. The hooded skunk, *M. macroura,* is either white backed or black backed. It is found from Central America to the southwestern United States. The spotted skunk, *Spilogale putoris,* of North and Central America, is 36 cm (14 in) long, with an 8- to 23-cm (3- to 9-in) tail, and may weigh nearly 1 kg (2.2 lb). Hog-nosed skunks, genus *Conepatus* are the only skunks in South America, and they also range northward to the southwestern United States.

Skunks are nocturnal, solitary feeders on both plants and small animals. They usually live in burrows.

skydiving Skydiving is the sport of jumping, with a (steerable) parachute, out of an airplane for recreation or in competition. Also called sport parachuting (see PARACHUTE), skydiving involves jumping from heights up to about 4,570 m (15,000 ft) and opening the chute(s) at 610–762 m (2,000–2,500 ft). Although higher jumps and lower chute openings have been accomplished, these parameters are considered safe.

Three major types of competition exist. One is accuracy jumping, in which the skydiver tries to land as close as possible to a target. Style jumping involves various near-balletic maneuvers attempted by the skydiver during free fall—the time in the air before the parachute is opened. In relative work a group of skydivers attempt simple or more complex linking maneuvers during free fall.

World championships, begun in 1951, are biennial. The world governing body is the Fédération Aeronautique Internationale, headquartered in Paris.

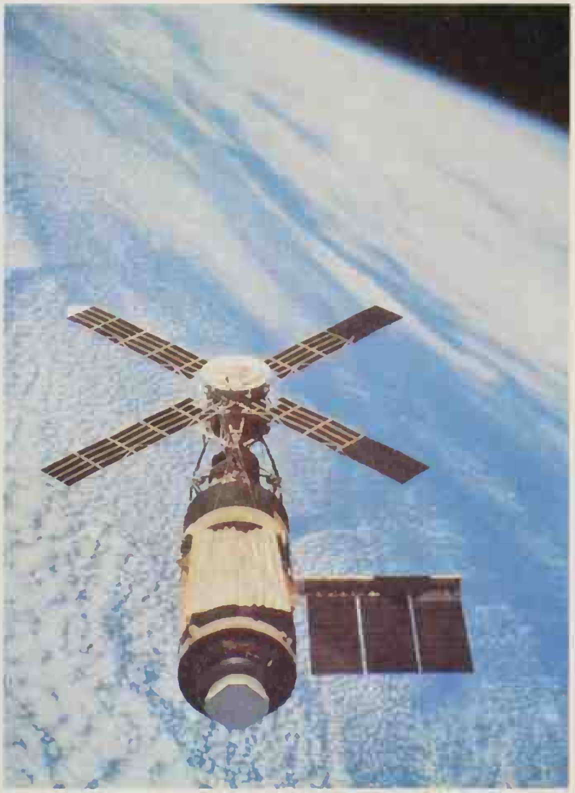
See also: AERIAL SPORTS.

Skye [sky] Skye is an island off the western coast of Scotland. The largest of the Inner Hebrides group, it has an area of 1,665 km^2 (643 mi^2) and a population of 8,139 (1981). The rugged Cuillin Hills in the southern part reach their highest point at Sgurr Alasdair (1,009 m/3,309 ft). Fishing, farming, weaving of tweed fabrics, and tourism are the main economic activities. Skye was ruled by the Norse between the late 9th and the 13th century, when it became part of Scotland.

Skye terrier The Skye terrier has a long, low outline and a long, profuse coat. The breed stands nearly 25 cm (10 in) at the shoulder and weighs about 11 kg (25 lb). The ears may be either prick or drop, and the tail is long and well feathered. The coat is double, with the outer coat hard and long. Plentiful hair on the head and muzzle obscures the eyes and forms a beard. Skyes range from black to blue, to light silver and gray, to fawn and cream. The ears, muzzle, and tail may have black points. Native to the Skye Islands and Scotland for hundreds of years, the breed became popular when Queen Victoria took an interest in it in 1842.

Skylab *Skylab,* the first U.S. manned orbiting laboratory, was launched on May 14, 1973; over the next 9 months it served as living and working quarters for three successive crews of astronauts. *Skylab*'s basic structure

This photograph of Skylab *was taken from one of the Apollo spacecraft that carried the crews to and from the orbiting laboratory. The sail-type sunshade* (center) *was deployed by the second crew to replace the original shield, torn loose shortly after launch.*



was a converted S-IVB rocket, the third stage of the *Saturn 5* booster designed to send Apollo spacecraft to the Moon. It provided a cylindrical shell enclosing a cabin about 14.6 m (48 ft) long and 6.4 m (21 ft) in diameter, with about 283 m^3 (10,000 ft^3) of usable living space.

Skylab's basic module was called the orbital workshop (OWS); attached to it were three other major sections. An astronomy section, the Apollo telescope mount (ATM), carried instruments for observing the Sun in the visible, ultraviolet, and X-ray portions of the spectrum. A second section, the multiple docking adapter (MDA), held the controls for the telescope array and provided the docking port for the Apollo spacecraft that carried the crews to and from the Earth. Separating the docking adapter from the workshop was an airlock module (AM) that housed various life-support, electrical, and communications systems and through which the astronauts passed to change film in the solar telescope. The workshop, airlock module, and docking adapter together provided about 360 m^3 (12,700 ft^3) of space, equivalent to a two- or three-bedroom house.

The first crew, consisting of astronauts Charles Conrad, Paul Weitz, and Joseph P. Kerwin, was launched on May 25, 1973, 11 days after the unmanned *Skylab* achieved its 432-km (268-mi) orbit. In addition to repairing *Skylab's* solar panels, the crew carried out an elaborate program of photography of the Earth to monitor volcanoes, earthquake faults, pollution, atmospheric conditions, and natural resources.

Astronauts Alan Bean, Jack Lousma, and Owen Garriott constituted the second crew, launched on July 28, 1973. Shortly after their arrival, Garriott and Lousma shared a 4-hour, record-setting spacewalk to deploy an external sunshade to help keep *Skylab*'s internal temperatures down. Astronomical and Earth photography were continued, along with various biological experiments to evaluate the effects of weightlessness on life forms such as minnows, plant seedlings, and spiders (observed to see if any changes occurred in their web-spinning patterns). The crew photographed several large solar flares as well as the optical source in the vicinity of the X-ray star Scorpio X-1. The crew also conducted several materials-processing experiments, such as welding and brazing, to study how the lack of gravity affected these techniques. They returned to Earth on Sept. 25, 1973.

The final crew—Gerald Carr, Edward Gibson, and William Pogue—was launched Nov. 16, 1973; they continued the types of experiments begun by the previous *Skylab* teams and also conducted extensive studies of the comet Kohoutek. The astronauts returned to Earth on Feb. 8, 1974. A command to the space station to turn off its telemetry transmitter was sent from Earth a day later.

Skylab was intended to remain in orbit until 1981–82, when it could be refueled by the Space Shuttle and regain altitude. NASA, however, underestimated the level of solar activity, which exerted a cumulative drag and caused the station's orbit to decay too rapidly. *Skylab* came to a fiery end on July 11, 1979, when it entered the Earth's atmosphere and disintegrated, showering debris over the Indian Ocean and uninhabited regions of Australia.

skyscraper A skyscraper is a tall, multistoried building usually designed for office or commercial use. Skyscrapers are of metal-frame construction in which a stable system of structural members supports curtain walls, floors, and roof. In bearing-wall construction the walls support the beams, which in turn support the floors and roof, restricting the height of the building.

Origins. By 1871, Chicago, with a population of 300,000, had become a major U.S. center of commerce. The famous fire on October 8 of that year left one-third of the city in ruins. In rebuilding Chicago, designers were freed from previous height restrictions by the use of ELEVATORS.

Construction of the first Chicago skyscraper began in 1883 with the ten-story (two stories were added later) Home Insurance Building, designed by engineer-architect William LeBaron JENNEY. It was the first building to employ an all-metal skeletal frame of iron and steel. The first all-steel frame was used by Daniel H. BURNHAM and John W. ROOT, in the construction of the second Rand McNally Building, completed in Chicago in 1890. The building was nine stories tall and reached a height of about 37 m (120 ft). Chicago's 20-story Masonic Temple Building by Burnham and Root, completed in 1891, became the tallest building in the world (84 m/274 ft). It was built with a lateral bracing system designed so that the planes of the building's exterior walls would resist high winds. The system consisted of diagonal rods connecting the beams and columns to form vertical trusses.

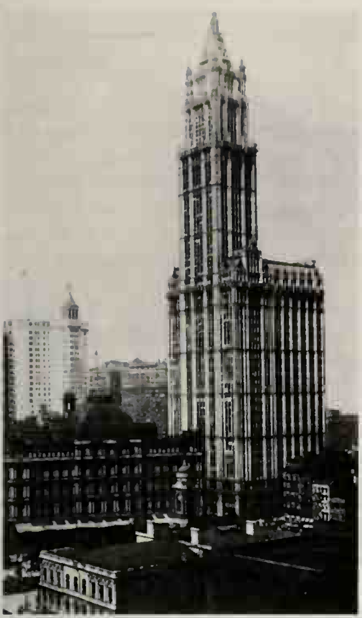
New York City's Giants. Chicago lost the race skyward to New York City in 1895 with the completion of Bruce Price's 21-story American Surety Building, elegantly remodeled (1975) as the Bank of Tokyo. In 1899, George B. Post's 16-story Saint Paul Building (94 m/310 ft) and R. H. Robinson's 29-story Park Row Building (118 m/386 ft) were completed.

From 1914 to 1929 the tallest building in the world was New York City's neo-Gothic WOOLWORTH BUILDING by Cass GILBERT. Its 60 stories reach a height of 241 m (791 ft). In 1930 it was topped first by the 70-story building at 40 Wall Street and several weeks later by the 77-story CHRYSLER BUILDING.

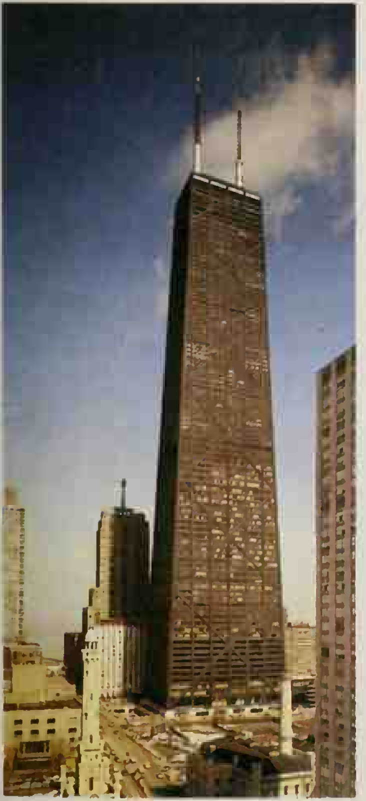
In May 1931, just one year later, the EMPIRE STATE BUILDING was officially opened. Its 102 stories reach a height of 381 m (1,250 ft). Erection of the beams, girders, and columns of the steel framework was completed in September 1930, just 23 weeks after the first piece of steel was placed.

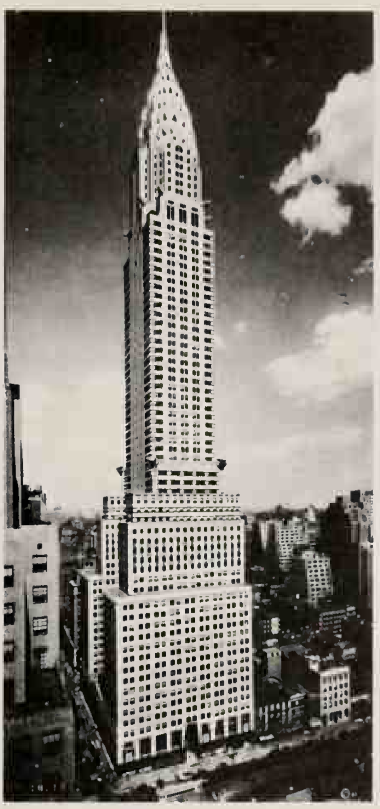
Post–World War II Skyscrapers. Following the Depression and World War II, skyscraper construction resumed on an ever-enlarging scale. The 110-story twin towers of New York's WORLD TRADE CENTER (1962–77) were, until 1974, the world's tallest buildings, at a height of 411 m (1,350 ft).

An entirely new type of skyscraper, Chicago's 100-story (337 m/1,105 ft) John Hancock Center, is a mini-city within one building, providing apartments, restaurants, banks, studios, and an observatory in addition to the usu-

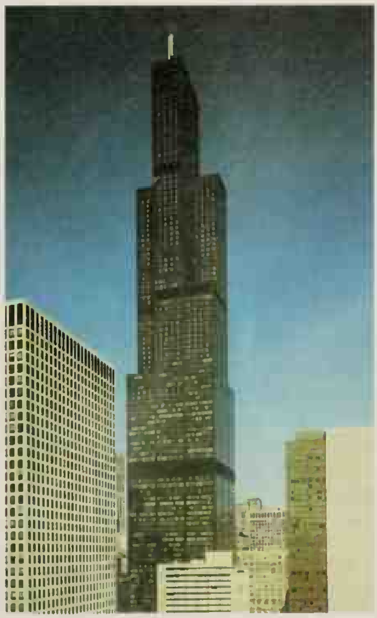


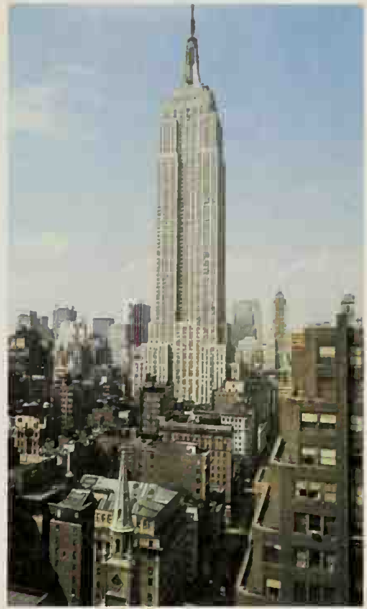
(Above) *The Woolworth Building (1914) in New York City, Cass Gilbert's Gothic Revival skyscraper, remained the world's tallest structure until 1929.* (Below) *Chicago's John Hancock Center (1970), designed by Bruce Graham, includes offices and shops.*



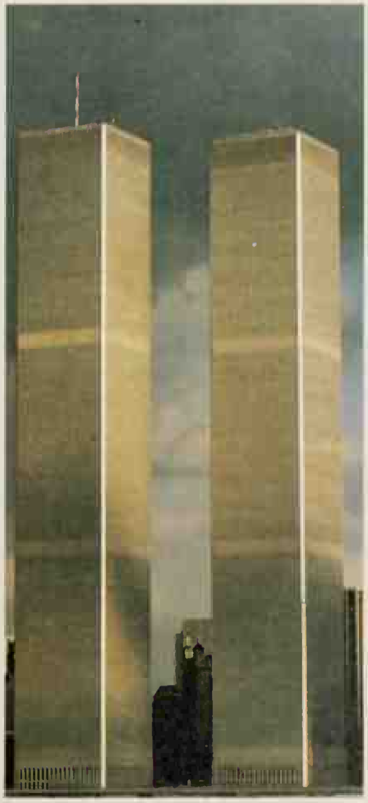


(Above) *Manhattan's Art Deco Chrysler Building (1930) by William van Alen rises 319 m (1,046 ft). The building was topped by the Empire State Building a year after its completion.* (Below) *Skidmore, Owings, and Merrill's Sears Tower in Chicago became the world's tallest building in 1974.*





(Above) *The Empire State Building (1931) is one of the most famous features of the Manhattan skyline.* (Below) *The 110-story twin towers of New York City's World Trade Center (1962–77), by Minoru Yamasaki, have been criticized for their bland exteriors.*



al parking garages and offices. The sides of the building slope inward to provide larger areas for offices on the lower floors and smaller areas for residential use on the upper floors. The highly visible exterior structural elements consist of the exposed exterior columns and horizontal spandrel beams, crisscrossed on each face of the building by six sets of X-shaped beams. These members form a tapered tower that resists gravity loads and wind forces like a cantilever beam anchored firmly in the ground. This design is unlike that of conventional tall buildings, in which the structural elements surrounding the elevator and stairway shafts, rather than the exterior elements, are designed to resist gravity and wind.

Chicago's SEARS TOWER, with 110 stories and a height of 443 m (1,454 ft), became the tallest building in the world in 1974. It consists of nine towers of various heights, each 23 × 23 m (75 × 75 ft) square, clustered together to form a single structure. This system offers great flexibility in the planning of interior space, whether for commercial or residential use.

The ultimate tower, the Mile-High Illinois skyscraper project, was designed by Frank Lloyd WRIGHT in 1956 but never built. In the form of a gigantic finned rapier, it was to have 528 floors and be one mile (1,611 m/5,286 ft) tall. Appropriately, Wright proposed that it be built in Chicago, birthplace of the skyscraper.

slander see DEFAMATION

slang Slang is a special vocabulary either limited to a particular social group or reserved for certain informal occasions. Members of groups ranging from nuclear scientists to pickpockets converse with one another in the slang or jargon of their profession. At times almost everyone uses slang—to strike a note of informality or to express an idea in an especially colorful or emphatic way.

The word *slang* itself did not become current until the latter part of the 18th century. Prior to the 17th century and the rise of the doctrine of correctness in English grammar and diction, the concept of informal slang may not even have existed. During the past few decades, as notions of linguistic decorum have faded, slang once again has begun to be limited to professional jargon.

See also: DICTIONARY; LEXICOLOGY AND LEXICOGRAPHY; SEMANTICS; SOCIOLINGUISTICS.

slapstick Derived from the flexible strip of wood, or slapstick, used to produce loud noises, as of beating, in the *commedia dell'arte*, the term *slapstick* now refers to any low comedy involving violent physical action such as clubbing and pie throwing. Transported to the United States by way of vaudeville and burlesque, slapstick dominated silent film comedy and the early periods of both sound film and television. Famous practitioners include Charlie Chaplin, Buster Keaton, Laurel and Hardy, the Marx Brothers, Jerry Lewis, Milton Berle, Lucille Ball, and Sid Caesar. More recently, Monty Python and Mel Brooks have combined slapstick with social satire.

slash-and-burn agriculture Slash-and-burn agriculture, sometimes called shifting cultivation, is an ancient form of farming traditionally practiced in central Africa, northeastern South America, and parts of the Indian subcontinent, Southeast Asia, and Oceania. In this method of agriculture, farmers cut down and set fire to the grass and trees so that the ashes fertilize the land they wish to cultivate. After a few years soil fertility declines rapidly, however, and weeds and pests appear. The farmers abandon the land and shift their cultivation to a new area, where they repeat the process of cutting, burning, and cultivating.

slate Slate is a hard, dense, and fine-grained low-grade METAMORPHIC ROCK that splits into thin slabs along planar surfaces. This splitting, known as slaty cleavage, results from recrystallization under pressure and commonly develops at an angle to the bedding planes. Slates are formed from clays, shales, volcanic ash, and other fine-grained rocks. Minerals present are quartz, sericite, chlorite, some graphite, titanium oxide, and iron oxides. Use of X-ray diffraction has shown that the hydrous aluminosilicate mineral pyrophyllite is a common subordinate constituent of slates rich in aluminum and poor in such alkalis as potassium and sodium. Some slates contain large crystals of pyrite, magnetite, chloritoid, and cordierite.

Slate is commonly found in areas where shale has been subjected to heat and pressure during mountain building. Because of its physical characteristics and its cleavage, slate has been used for a great variety of surfaces, including roofing tiles and billiard table tops.

Slater, Samuel [slay'-tur] Samuel Slater, b. Derbyshire, England, June 9, 1768, d. Apr. 20, 1835, founded the U.S. textile industry. After working closely with Sir Richard ARKWRIGHT's partner, Jedediah Strutt—and despite a British law forbidding the emigration of textile workers—Slater went secretly to the United States in 1789. In Rhode Island he reconstructed Arkwright's spinning and carding machines from memory. The first U.S. cotton mill was founded (1793) in Pawtucket, R.I., and Slater subsequently built textile mills throughout New England.

Slatkin, Leonard Leonard Slatkin, b. Los Angeles, Sept. 1, 1944, is one of only two eminent American conductors, the other being Leonard Bernstein, to have been trained entirely in the United States. The son of conductor Felix Slatkin, he graduated from New York City's Juilliard School of Music in 1968 and was appointed assistant conductor of the St. Louis Symphony; he became principal conductor in 1979. Slatkin has transformed the St. Louis Symphony into a major musical ensemble, and he is in demand worldwide as a guest conductor.

Slave River The Slave River of Canada, 415 km (258 mi) long, flows from Lake Athabasca in northeastern Alberta through Wood Buffalo National Park to Great Slave Lake in the Northwest Territories. Its main tributary is the PEACE RIVER. Samuel Hearne named (1771) the river for the Slave Indians.

slavery Slavery is a societal institution based on ownership, dominance, and exploitation of one human being by another. The owner may exact work or other services without pay and virtually without restriction and can deny the slave freedom of activity and mobility. Generally the owner is responsible only for providing minimal food, shelter, and clothing. A slave is commonly regarded as an article of property, or chattel, and therefore can be sold or given away. Slaves do not come under the jurisdiction of laws that protect citizens, although special regulations may stipulate their treatment and behavior.

Slavery has appeared almost universally throughout history among peoples of every level of material culture. It is not unique to any particular type of economy. Among agriculturists, where surplus production led to material and cultural advancement, slaves were valued primarily as the major work force in production. Such societies are sometimes referred to as commercial slave societies, exemplified by the Roman Empire and the Old South of the United States, distinguishing them from societies in which slaves were used principally for personal and domestic service, including CONCUBINAGE. The latter type of slavery traditionally existed in parts of the Middle East, Africa, and China.

Slavery in the Ancient World

The legal codes of SUMER provide documentary evidence that slavery existed there as early as the 4th millennium BC. The Sumerian symbol for slave, in cuneiform writing, suggests "foreign." Slaves were, in fact, almost always of a different ethnic group, race, religion, or political unit from their owners. The earliest slaves were probably war captives, although debt slaves also existed in ancient Egypt, where a person could sell himself or his wife and children into bondage to liquidate debts.

An Egyptian slave endures a flogging in this fresco from a tomb of the New Kingdom. The number of slaves in Egypt increased dramatically during the New Kingdom (1570–1085 BC) as a result of foreign conquests.

Roman soldiers round up war captives for sale as slaves. In Rome, as in the other ancient societies, war was a primary source of slaves.

The Code of Hammurabi, king of Babylonia in the 18th century BC, detailed many laws pertaining to slaves (see HAMMURABI, CODE OF). The code of the HITTITES, in effect in western Asia from 1800 to 1400 BC, first conceded that a slave was a human being, although of an inferior order. Ancient Egyptian society was also heavily dependent on slave labor, and slave owners had absolute rights. The ancient Israelites experienced slavery in Egypt during the second half of the 2d millennium BC, but the Hebrews themselves adhered to a slave system. The Old Testament stipulated a limit of 7 years to the period of servitude, although the biblical 7-year limit was apparently not always honored.

In the Indus Valley the first documented evidence of slavery coincides with the ARYAN invasion of about 1500 BC. Ancient Indian literature indicates that slavery was sanctioned throughout India from the 6th century BC to the beginning of the Christian era. In ancient Persia slave breeding became a major source of supply in addition to slave acquisition through conquest. Persian victories in the Aegean islands of Chios, Lesbos, and Tenedos resulted in the enslavement of entire populations.

The poems of Homer supply evidence that slavery was an integral part of ancient Greek society, possibly as early as 1200 BC. Plato opposed enslavement of Greeks by Greeks, regarding bond servants as essentially inferior beings. His pupil Aristotle considered slaves as mere tools, lucky to have the guidance of their masters. Wars, piracy, and debt were the main sources of slaves for the Greeks.

At the Laurium silver mines in Attica from 10,000 to 30,000 slaves were used at a time. Bound in chains, they were forced to work in appalling underground conditions and were brutally flogged. Household slaves, artisan-slaves, slaves in minor official positions, and public slaves who served the temples seem to have been treated with greater leniency. Laws protected them from excessive abuse, but they were nonetheless chattels, without rights in courts of law. Manumission might be achieved by self-purchase, as a gift for outstanding service, or by bequest in a deceased owner's will.

In Roman times, the Carthaginian, Punic, Gallic, and other wars yielded enormous numbers of slaves and produced a slave population eclipsing any in earlier history. Plutarch notes that on a single day in the year 167 BC, 150,000 slaves were sold in a single market. Syria, Galatia, North Africa, and Gaul were the most productive regions in satisfying the needs of the vast slave system. Owners had virtually unrestricted power, and treatment was truly barbaric. Such conditions, combined with the numerical superiority of slaves over free men, inevitably led to large-scale revolts, such as that fomented by the Thracian slave SPARTACUS, who in 73 BC escaped to Sicily and formed an army of 40,000. More merciful treatment of slaves prevailed during the reign of Claudius, at the beginning of the Christian era. Slaves of that period often fared better than poverty-stricken free Romans, and some slaves rose to occupy fairly important positions in government. Their great numerical preponderance, which diluted the mass strength of the free population, is presumed to have contributed eventually to the downfall of the Roman Empire.

Slavery in the Middle Ages

As the centralized power and discipline of Rome weakened, agricultural slaves gradually evolved into coloni, or tenant farmers, on large estates. Change of status, however, was more technical than actual because the tenant farmer was perpetually in debt to the landowner and bound to the land and to labor by his debts. The advent of Christianity did not interrupt this or any other slave system because the New Testament, like the Old Testament, did not specifically prohibit slavery.

In the New World the Spanish and Portuguese enslaved large numbers of indigenous Indians—men, women, and children. Chattel slavery was soon replaced by the forced labor systems of encomienda *and* repartimiento.

By a further gradual evolution as Europe entered the Middle Ages, the coloni became serfs under the manorial system (see MANORIALISM), bound to a lord by a complex system of interrelationships. The serf pledged labor, loyalty, and some material payment in return for protection by the lord of the manor and the use of a piece of land to farm for his own subsistence. In Russia serfdom prevailed long after the end of the system in Europe; under Peter the Great serfs regressed to the condition of slavery.

In the East slavery was an entrenched institution long before the coming of Muhammad in the 6th century AD, and Islam did not change the situation. The Koran, like the Bible, failed to condemn slavery, although it advocated humane treatment. Nevertheless, as war followed war, entire populations were reduced to slavery. During the Crusades, Christians enslaved Muslims. Muslim pirates in the Mediterranean enslaved Christian passengers and sailors captured in raids on shipping.

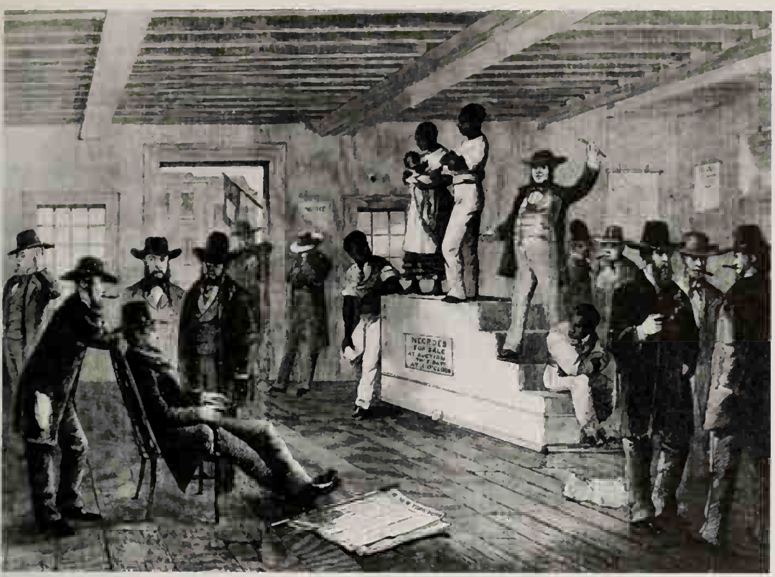
Slavery in the New World

Slavery in Spain and Portugal, long an established institution, had continued throughout the Middle Ages, and the discovery of the New World in the 15th century created an unprecedented demand there for human labor. The demand was temporarily satisfied by the virtual enslavement of whole indigenous Indian populations from Peru to Central America and Mexico. The forced labor systems of ENCOMIENDA and repartimiento instituted by the Hispanic colonists proved neither practical nor satisfactory, however. The Indians, by reason of physique, tradition, and susceptibility to European diseases, were not ideal slaves. Also, being in their homeland, escape or revolt was relatively easy for them.

Coincidentally, Portuguese ships exploring and raiding the coasts of Africa found a promising labor force. Thus began the importation of black Africans to the New World as slaves. The British, French, and Dutch, as well as the Spanish and Portuguese, put blacks to work on the great sugar plantations, the loci of a particularly cruel form of slavery.

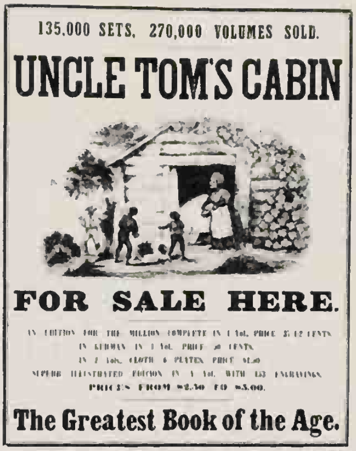
The African Slave Trade. Slavery had been common for centuries in African tribes, as in other tribal societies (see AFRICA, HISTORY OF). Slaves were usually captives taken in raids or wars. They enhanced the power and wealth of tribal chiefs. When European slave ships first appeared along the African coast, chiefs met them at the shore to barter human wealth for merchandise such as weapons, ammunition, metal, liquor, trinkets, and cloth. The slavers bought only the finest physical specimens, partly because they would be worth more at their destinations and partly because only the youngest and healthiest had a good chance of reaching their destinations alive.

Slavery in the English Colonies. The first slaves to arrive in the English colonies in America, about 20 in number, were put ashore at JAMESTOWN, Va., in 1619. At that time the Africans were classed with white indentured servants brought from England under work contracts. Decades passed before blacks in any significant number were brought to the colonies; in the main, they replaced escaped or freed indentured servants.



(Above) *A Virginia slave auctioneer calls for bids on an African couple and their baby. The indifference of the buyers may reflect an attempt to hold the price down or an unwillingness to buy the family as a unit. Families were often broken up at such sales.*

(Below) *Harriet Beecher Stowe's popular novel* Uncle Tom's Cabin *helped to intensify antislavery sentiment in the United States. Abraham Lincoln said that the book started the Civil War.*



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FOR SALE HERE.

The Greatest Book of the Age.

The Indian tribes who lived in and near the English colonies seemed natural subjects for enslavement, as had the Indians in Spanish America. Indian slavery was attempted, but Indians did not make as satisfactory slaves as blacks. For one thing, they were less accustomed to the settled agriculture at which they were expected to labor. Also, although some Indian groups, including the Aztec and Maya and the Cherokee, Chinook, Natchez, and Nootka, had practiced slavery themselves, their variety was generally even less like the chattel slavery of the colonies than was the domestic and political slavery of the Africans. Perhaps most importantly, Indians were in their own homeland, where they were organized into tribes and nations; they were in a position to rise up and kill those who tried to deprive them of their liberty. By the time the colonists were sufficiently numerous and organized to enforce slavery on the Indians, an easier solution was presented by the ever-larger number of more helpless black foreigners put on the block.

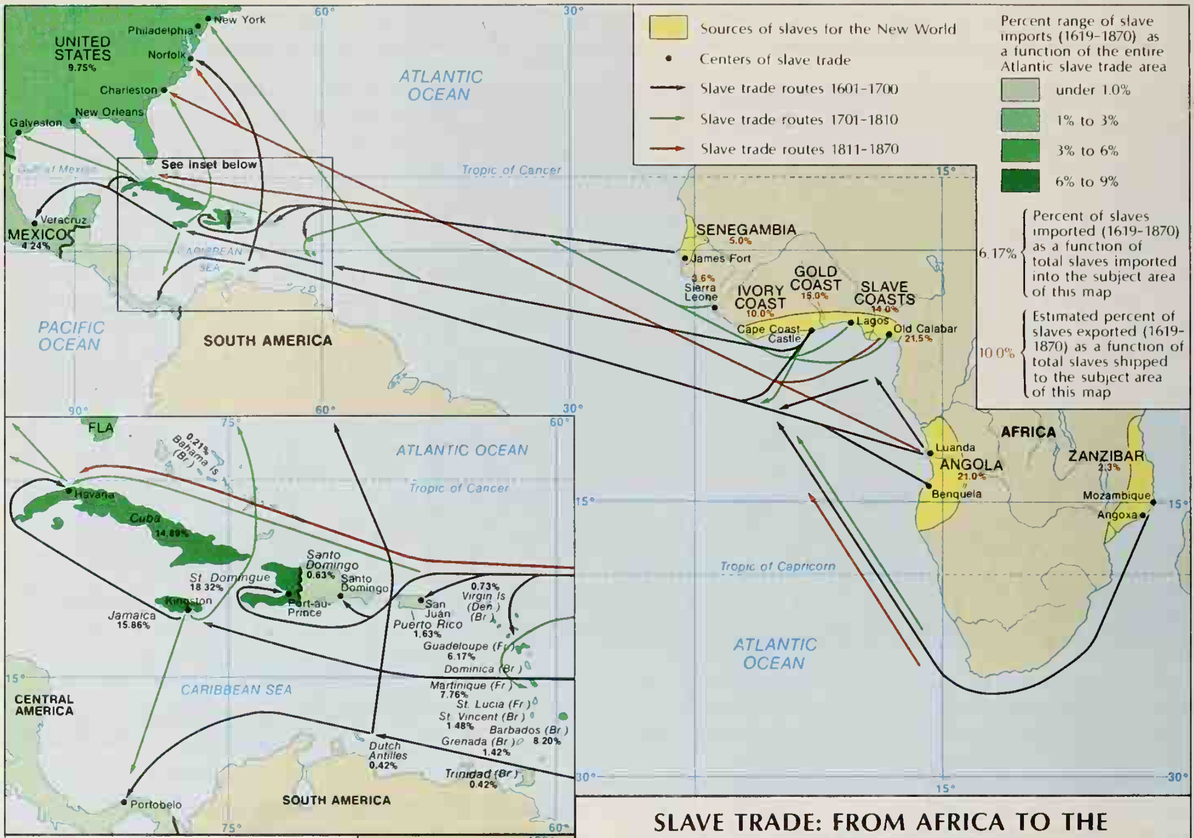
The Triangle Trade. Demand for slaves to cultivate crops of tobacco and, farther south, rice and sugarcane stimulated a systematized traffic in slaves called the triangular trade. Ships leaving England with trade goods touched first at the west coast of Africa and sold their merchandise for African blacks. After the notorious "Middle Passage" from Africa, the next stop was either the West Indies, where slaves were in demand on plantations, or the English colonies; at this stop the slaves were exchanged for such agricultural products as sugar. The return voyage to England with a valuable cargo completed the triangle.

As the trade developed, New England ports became a regular stop before the homeward crossing; there, sugar and molasses acquired at earlier stops were in demand for the manufacture of rum. The point on which the triangular trade precariously balanced was the African slave, who was a source of wealth to tribal chiefs, to the shipping business, to plantation owners in the South, and to merchants and shipbuilders in the North. A trade profitable to so many was bound to grow. An estimated 8 to 15 million Africans reached the Americas from the 16th through the 19th century, with a peak of about 6 million arriving in the 18th century alone. As the number of slaves increased, rebellions also increased (see Gabriel, slave; Turner, Nat; Vesey, Denmark). Punishment was severe, ranging from branding and maiming to hanging. (See also African Americans.)

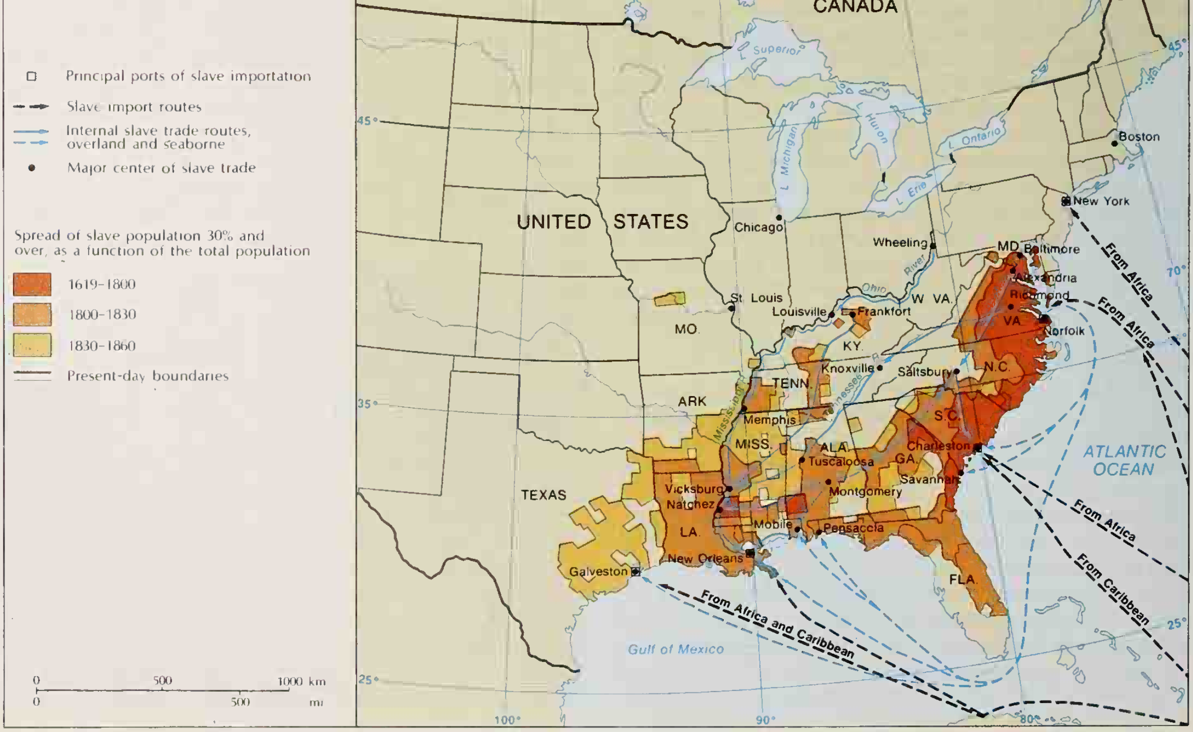
Opposition to Slavery

The first organized opposition to slavery in the American colonies came from the Quakers (see Friends, Society of), who made their first statement against slavery as early as 1724. Although slave markets existed in both the North and South, an increasing number of colonists regarded slavery as unnecessary and undesirable. Individual states abolished slavery, beginning with Rhode Island in 1774, but the U.S. Constitution, ratified in 1788, provided for the continuance of the slave trade for another 20 years. Slavery was so tightly woven into the fabric of the country's agricultural and commercial life that to most people abolition seemed unthinkable. Slavery was excluded from the Northwest Territory by the Ordinance of 1787, but whatever was gained by this action seemed nullified by the vastly increased demand for field hands to raise and

SLAVE TRADE: FROM AFRICA TO THE CARIBBEAN AND THE UNITED STATES



SLAVE TRADE INTO THE UNITED STATES



pick cotton as Eli Whitney's cotton gin, invented in 1793, came into general use. The value of a strong, young male slave rose from $500 in the early 1830s to $1,800 in the late 1850s.

In Britain, following a rising antislavery movement led by abolitionists William WILBERFORCE and Thomas Clarkson (1760–1846), the British Parliament outlawed (1807) the slave trade, authorizing search and seizure of suspect ships and payment for the liberation of slaves. In 1833, Britain entirely outlawed slavery. As South American countries won their independence, they too made slavery illegal; debt peonage, however, often took its place. By 1840, Spain and Portugal had officially abolished traffic in slaves, but Portuguese ships continued their crossings, remaining a major source of smuggled slaves throughout the 18th and 19th centuries.

In the United States, antislavery feeling achieved significant momentum in 1831 with the publication of William Lloyd GARRISON's abolitionist newspaper, *The Liberator.* The formal founding of the ABOLITIONIST movement came with the inauguration of the American Anti-Slavery Society in Philadelphia in 1833; by 1840 the UNDERGROUND RAILROAD was active in helping slaves escape to the North, to freedom. As the tide of protest to slavery mounted, abolitionists were condemned and persecuted. New converts, however, raised a public outcry, spurred on by the annexation of Texas (1845), which created a huge new slave state; the FUGITIVE SLAVE LAW (1850); the violence caused by the KANSAS-NEBRASKA Act (1854); and John BROWN's raid on Harpers Ferry (1859). Books such as Harriet Beecher Stowe's UNCLE TOM'S CABIN stimulated antislavery sentiment in the North, but apart from opposing the further spread of slavery, few actively supported abolition until it became the major issue in the presidential campaign of Abraham LINCOLN. Lincoln summed up the political, if not the humanitarian, problem of slavery in his speech accepting the presidential nomination, saying that the nation could not survive half-slave and half-free. The U.S. CIVIL WAR was fought to decide the issue of slavery, a war that resulted in almost 900,000 casualties and indescribable suffering for many more. The slaves were declared free during the war by Lincoln's EMANCIPATION PROCLAMATION (1863). With the passing of the 13TH AMENDMENT (1865) slavery was constitutionally abolished in the United States.

Slavery during the Twentieth Century

Although the United States had put an end to slavery as that institution is here defined, a form of it persisted in tenant farming, debt peonage, and migrant labor, in the sense of work contracts that yield the worker little or no profit from labor or leave the worker perpetually in debt to the employer. In North America, Hispanics, Mexicans, and African Americans suffer the most from such systems. Elsewhere in the world, notably in parts of Africa, Asia, and South America, these and more literal forms of slavery persist. The Anti-Slavery Society for the Protection of Human Rights in London estimates that debt bondage (in which impoverished, illiterate people work for very low wages, borrow money from their employers, and pledge their labor as security), serfdom that is called contract labor, sham adoptions, servile forms of marriage, and other forms of servitude still oppress more than 200 million poor people in the developing world. In the late 1980s the society concentrated its efforts to improve the lot of such people in South and Southeast Asia because of the magnitude of child-labor servitude there. The society estimated that 50 million children in India alone were being exploited. The sale of children into bondage and the self-sale of impoverished persons also continue in Asia.

Saudi Arabia and Angola abolished slavery officially only in the 1960s. In Angola subsequently, however, contract workers in mines and on plantations, highways, and railroads seemed to be involuntarily conscripted and were paid the equivalent of only a few cents a day. Observers confirm reports of unacknowledged slavery in other African countries.

The 20th century has nevertheless made some forward strides toward human freedom through international organizations. The League of Nations, formed following World War I, set up machinery for international cooperation toward putting an end to slavery everywhere. The League's successor, the United Nations, has continued and expanded the work of the League. Its Declaration of Human Rights (1945) specifically prohibits slavery and the slave trade, and the Security Council has condemned forced labor. Perhaps more important than any declaration or agreement opposing slavery is the work of international bodies that attack the conditions of hunger, weakness, and ignorance, which perpetuate the institution of slavery.

Slavic languages [slah'-vik] The Slavic, or Slavonic, languages form one of the branches of the INDO-EUROPEAN LANGUAGES; they share a number of features with the BALTIC LANGUAGES.

Major Branches. In the 5th and 6th centuries AD, after the collapse (453) of the Hunnish empire, the Slavic peoples migrated south and east through and around the Carpathians, north into the upper Dnepr region, and west as far as the Elbe. Three main linguistic branches crystallized as a result of the migrations. One was the West Slavic branch, comprising Polabian (extinct since the 18th century, spoken in the Elbe region), Kashubian (spoken on the left bank of the lower Vistula), Slovincian (which survived into the 20th century in the Stołp district of Poland), Polish (with 40 million speakers in present-day Poland), High and Low Sorbian (also called Lusatian or Wendish, still used by about 100,000 speakers on the upper Spree in Germany), Czech (10 million speakers), and Slovak (5 million speakers in present-day Czechoslovakia). The second branch is known as South Slavic. It comprises Serbo-Croatian (18 million speakers in present-day Yugoslavia), Slovenian (2 million speakers in northwest Yugoslavia), Macedonian (2 million speakers in southeast Yugoslavia), and Bulgarian (9 million speakers in present-day Bulgaria). The third is the East Slavic branch, within the USSR, and comprises Russian (154 million speakers), Ukrainian (37 million), and Belorussian (7 million).

Old Church Slavonic. By the 9th century the Slavic peoples were spread over a wide geographical area, yet they spoke a common language with only minor differences in dialect. No credible evidence attests to Slavic writing prior to the 860s, when Prince Rostislav of Moravia requested teachers "in our own language" from Byzantium. The two brothers who headed this mission, Constantine (Saint Cyril, 827–869) and Methodius (826–885), created a Slavic alphabet, glagolitic, and began to translate church books and homiletic and liturgical texts. Before Methodius's death, many translations and even original works, including poetry, had been written in the new literary language, called Old Church Slavonic. Near the end of the 9th century, glagolitic was replaced by Cyrillic, derived primarily from the Greek uncial script.

Modern Vernaculars. In the South Slavic territory, a progressively modified Church Slavonic remained the exclusive written language for the orthodox Serbs, Macedonians, and Bulgars, and for some Croatian Catholics. The Slovenes replaced Church Slavonic with the vernacular in the 16th century, and the Serbs did so early in the 19th. By 1850 a common Serbo-Croatian literary language had been elaborated, written by the Croats in the Latin alphabet and by the Serbs in Cyrillic. Modern Bulgarian emerged in the mid-19th century, Macedonian after World War II.

Old Church Slavonic was suppressed in the West as early as the 11th century; consequently the West Slavic languages use a Latin alphabet. Church Slavonic was used in the East, however, well into the 18th century. In Russian the modern literary language grew from an enrichment of the vernacular through Church Slavonic; by contrast, the Ukrainians based their language primarily on the vernacular.

Linguistic Features. The language used by all Slavic peoples before their historical period, called Common Slavic, still conserved most of the Indo-European case system, although the ablative had merged with the genitive. In addition to the singular and plural numbers, Old Church Slavonic also had a dual number, preserved today only in Slovenian and Sorbian. Slavic substantives and adjectives still have masculine, feminine, and neuter genders in the singular, but the gender distinctions are lost in the plural in Russian and Bulgarian and have weakened in the other modern languages. Word order has remained relatively free in Slavic.

In the 18th century, Slavic scholars realized that their languages possessed a grammatical category not shared to any appreciable extent by other Indo-European languages: verbal aspect. Every verb is classified today as belonging either to the marked, or perfective, aspect or to the unmarked, or imperfective, aspect. A perfective verb focuses attention on a certain phase or aspect of the verbal action—the onset of action, for example, or its completion, or the action taken as a whole. An imperfective verb simply describes the verbal action with no particular focal point.

Old Church Slavonic possessed an elaborate set of verb forms—up to 236 for an imperfective verb. All but Eastern Serbo-Croatian, Macedonian, and Bulgarian have lost the aorist and imperfect tenses. In these languages the old perfect has come to signify a past action not witnessed by the speaker; the perfect form is used in the other Slavic languages to signify a nonpresent tense, most commonly the past, but it is also used in conjunction with an auxiliary form to denote the conditional (as in Russian or Czech) or even the future (as in Slovenian).

Slavonia Slavonia (Serbo-Croatian: Slavonija) is a historic region, today forming the easternmost portion of the Republic of Croatia. Its principal cities are Osijek, Vinkovci, and Slavonski Brod. Originally a separate territory, Slavonia became associated with Croatia in medieval times. In 1091 both were conquered by LADISLAS I of Hungary, whose successors assumed the title "king of Dalmatia, Croatia, and Slavonia." The eastern part of Slavonia was occupied by the Turks in the 16th and 17th centuries, but the territory was reunited under Austrian rule early in the 18th century. From then until the dissolution of Austria-Hungary in 1918, Croatia-Slavonia was a constituent kingdom of the Hungarian monarchy. From 1918 to 1922 it was part of Yugoslavia.

Slavophiles and Westernizers [slahv'-uh-fylz] Slavophilism and Westernism were two expressions of romantic nationalism in Russia that clashed during the reign (1825–55) of Emperor Nicholas I. Slavophiles held that it was only the three uniquely Russian institutions—the Orthodox church, the village commune, and the autocracy—that had enabled Russia to maintain its supposedly superior spiritual nature instead of becoming morally bankrupt like the egotistic, rationalistic West. Many of the Slavophiles' ideas were incorporated into PAN-SLAVISM in the latter half of the 19th century. The Westernizers, whose spokespersons included Aleksandr HERZEN, believed that Russia had to absorb Western social reforms and technological developments because the more advanced Western nations provided a rough guide for Russia's own future.

Slavs [slahvz] The Slavs are the largest mass of European peoples sharing common ethnic and linguistic roots (see SLAVIC LANGUAGES). Classical authors during the 1st century AD mention Slavs, and some scholars maintain that the Greek historian Herodotus wrote of the Slavs in the 5th century BC. Originally Asian, the Slavs migrated to Europe for economic and political reasons.

Various Slavic groups living in eastern Europe were conquered by the Huns during the late 4th century AD. The subsequent dissolution of the Hun empire during the mid-5th century sparked the great migration of the Slavs westward, southward, and northward. Slavic groups have been classified as Antae, or East Slavs (Great Russians, White Russians, and Ukrainians); Sklaveni, or South Slavs (Serbs, Croats, Slovenes, Macedonians, Montenegrins, Bosnians, and Bulgarians); and Venedi, or West Slavs (Poles, Czechs, Slovaks, and Wends).

The Slavs first became a potent political force under Samo, a Frankish merchant who mobilized the Wends (also called Sorbs or Lusatians) and became their king (r. *c.*623–58), defeating the nomadic Avars from Asia and ending (630) the domination of the Wends by the Merovingians. During the century and a half after Samo's death the Wends were again subjugated by the Avars. The destruction of the Avar empire by Charlemagne led to the establishment of a Moravian kingdom, which reached its height under Svatopluk (d. 894); he ruled parts of what are now Bohemia, Moravia, Poland, Slovakia, and Hungary. At this time Saints CYRIL AND METHODIUS introduced Christianity. The Moravian kingdom was destroyed by the Magyars during the early 10th century.

Also during the 10th century several Slavic states were established. In what is today Bulgaria, SIMEON I created a powerful empire, a small Croatian polity emerged, the Bohemian state under the Přemysl dynasty was integrated into the German empire, and the PIAST family created a Polish state. These groups were generally affiliated with the Roman Catholic church.

The Kievan state, which thrived from the 10th to the 13th century, was the first medieval state of the eastern Slavs. It was founded by the Varangians from Scandinavia; under the RURIK dynasty Kievan Russia grew by conquest and annexation to include modern Ukraine and Belorussia. The Viking overlords gradually merged with the Slavic inhabitants of the Kievan state, who were converted (*c.*989) to the Byzantine form of Christianity. Kiev dominated Russia until the Tatar-Mongol conquest of 1240.

Slayton, D. K. [slay'-tuhn] The American astronaut Donald Kent "Deke" Slayton, b. Sparta, Wis., Mar. 1, 1924, was the last of the original seven astronauts to fly in space. Slayton earned his army air force wings in 1943, then flew 63 bombing missions during World War II. He graduated from the University of Minnesota in 1949 and served as an air force test pilot from 1956 to 1959, when he was selected as one of the first seven U.S. astronauts. His first flight was to have been the second Mercury program mission, but concern over a previously undiscovered heart murmur prompted NASA officials to replace him. In 1963, Slayton resigned his commission as an air force major and became director of astronaut flight-crew operations (1963–74). He returned to flight status in 1972 after a decade of intensive exercises had cleared up his heart irregularity, and served as the docking module pilot on the Apollo-Soyuz Test Project (July 15–24, 1975). Slayton was manager (1976–77) of the approach and landing tests for the SPACE SHUTTLE program and in 1978 was named manager of the first six Space Shuttle orbital flight tests. He retired from NASA in 1982.

sled The sled, commonly called a sledge by English-speaking peoples outside the United States, appeared in various primitive cultures. Early sleds were probably pieces of hide or bark that were pulled by humans in transporting killed animals. Sleds were generally used for transportation over ice and snow. Bone and wooden runners, or even logs, were used on the earliest sleds, but eventually they were replaced with metal. The usefulness of the sled increased when domesticated draft animals were used for traction, for example, the dog in northern Europe. After larger draft animals such as the horse and reindeer were domesticated, much greater loads could be transported. Sleds are used primarily today for recreational purposes.

sleep Humans spend about one-third of their lives in sleep. Along with food, water, and shelter, sleep is essential to normal function. Without sleep, mental and physical processes steadily and progressively deteriorate. The longer the period of sleep deprivation, the more likely it is that effects such as headaches, irritability, attention lapses, extreme emotionality, and even psychotic reactions will be experienced.

Scientists have only in the past few decades begun to assess precisely how sleep differs from the waking state. Sleep, they have discovered, is not a unitary state. That is, many levels and types of sleep exist, each with its own set of physiological parameters. For instance, the body goes through a number of biological changes about every 24 hours. These daily, or circadian, rhythms are evident when variables such as body temperature, heart rate, and blood pressure are measured. Each variable rises and falls in a fairly predictable pattern during each day. Usually humans are at their most active and efficient when body temperature is at its peak, and at their least efficient when body temperature drops to its nadir. In the normal individual the greatest slowdown in these biological processes occurs during the state called sleep. Sleep is not, however, a sudden and abrupt change from wakefulness. Rather, sleep involves gradual changes in various circadian rhythms, which appear to have several stages or depths (see BIOLOGICAL CLOCK).

The Stages of Sleep

A great deal of current knowledge about the stages of sleep comes from the use of a sophisticated recording instrument called the ELECTROENCEPHALOGRAPH, or EEG. With this instrument the scientist is able to measure and observe the electrical activity of the brain by placing sensitive electrodes on the scalp, amplifying the tiny signals produced by the brain, and printing these signals. In this way it has been discovered that the brain shows many distinct patterns of electrical activity, in both the sleeping and the waking state.

Rapid Eye Movement. Basically, sleep can be divided into "orthodox" or Non-Rapid Eye Movement (NREM) sleep and "paradoxical" or Rapid Eye Movement (REM) sleep. During REM sleep, scientists discovered, the eyes move rapidly even though the eyelids are closed. When people are awakened from REM sleep, they usually report that they have been dreaming (see DREAMS AND DREAMING; NIGHTMARE).

Sleep Phases. A typical night's sleep might be described as follows: first, during stage 1 of NREM, a transitional phase occurs between sleep and wakefulness, and the sleeper reacts less to external stimulation. This phase is known as hypnogogia. After about 5 minutes the sleeper moves to stage 2, and the EEG shows a pattern called sleep spindles. During stage 3, or delta sleep, the brain shows a pattern of delta waves, which are slower and greater in amplitude than waves characterizing the preceding stages. After some period of time in stage 3, the sleeper usually returns to stage 2 for a while.

About 90 minutes after the sleeper falls asleep, the first REM or dream period begins. During REM, brain activity in some ways resembles the waking state, but muscles are extremely relaxed. Thus REM is sometimes called paradoxical sleep, because it has characteristics of both waking and sleeping.

Usually the dream period lasts only 5 to 10 minutes, after which the sleeper returns to stage 2 and then back to another short REM period. This cycle of stage 2 and REM tends to alternate in about 70- to 90-minute periods for the rest of the night. All healthy sleepers have about four REM periods in a night, even if the sleeper cannot recall having dreamed. About 20 to 25 percent of the total sleep time is spent in REM. REM periods gradually lengthen throughout the night, and most of the latter part of a night's sleep is spent in REM.

Biochemical Activity. During REM sleep, changes in levels of various HORMONES and chemicals occur. For instance, the amounts of certain hormones in the bloodstream decrease. As a result, brain temperature increases and breathing becomes more rapid. During NREM sleep, serotonin, an indole amine found in the brain, increases in level. Monoamine oxidases are enzymes that are active during the transition from NREM to REM sleep.

Sleep Periods

The amount of nightly sleep that healthy individuals require varies widely from person to person and is considered to be a biological attribute, like weight. Although there is no "normal" length of a good night's sleep for a given age group, sleeping requirements generally decrease with age. Adults sleep, on the average, between 7 and 8 hours each night, with individual averages ranging from 4 to 10 hours. Studies have shown that a person forced to sleep slightly less each night, because of a job, school, and so on, will still function normally. After an initial adjustment period in which there is an increase in the amount of deep sleep and a decrease in the amount of REM sleep, the body reverts to normal relative amounts of both types. If the change in sleep-period length is not severe, the body can seemingly operate under the new conditions indefinitely. Even periods without sleep of up to one week do not appear to harm the body seriously.

Sleep Disturbances

From the number of over-the-counter medications available for sleep problems, and from the number of prescriptions written for sedatives and tranquilizers, it may be assumed that many people believe that they do not sleep well. Of course, almost every individual has experienced sleep problems at some time in life, but for some people these problems become chronic and extremely debilitating.

One way of classifying sleep disorders is according to whether they are the principal or only symptom of disturbance, or whether they are secondary to some larger problem. Among the primary disorders are narcolepsy, in which the individual almost uncontrollably falls asleep at any moment, and APNEA, in which the sleeper actually stops breathing for short periods of time. Narcolepsy is, at least partially, a genetic disorder characterized by sleepiness, attacks of physical paralysis, and hallucinations. The symptoms are sometimes triggered by emotional stimuli and are possibly related to abnormal amounts of dopamine and acetylcholine in the brain. Narcolepsy has been effectively controlled by the use of amphetamines. Sleep apnea occurs most often in obese, middle-aged men with hypertension, who snore loudly. It is caused by blockage of the air passage by tongue, tonsils, or sinus nodes and can be treated with drugs or surgery. Instances of death in sleeping infants, known as Sudden Infant Death Syndrome, or SIDS, may also involve apnea (see CRIB DEATH).

By far the most common of the primary sleep disorders is insomnia, characterized by extremely slow sleep onset or repeated awakenings during the night. (In the condition called pseudoinsomnia, the individual claims to be unable to sleep, but independent observations show that the subject has indeed slept through the night.) Insomnia may also occur secondary to various medical, psychiatric, or behavioral problems. For instance, people who excessively use either stimulant or sleep-inducing drugs may experience disturbed sleep. Sleep disorders also are fairly common among depressed or psychotic patients and among chronic alcoholics. Insomnia may be a problem for people who are tense, anxious, or worried. In these situations, a vicious cycle may develop in which the harder a person tries to fall asleep, the less that person is able to relax and actually sleep. Focusing on the primary problem as well as on the sleep disturbance generally effects a cure for many secondary sleep disorders.

sleeping sickness see TRYPANOSOMIASIS

sleet see PRECIPITATION (weather)

slide rule A simple mechanical device for making rapid mathematical calculations, the slide rule can be used to multiply, divide, find powers and roots, and perform more complex operations involving logarithms and trigonometric functions. It cannot, however, be used for simple addition or subtraction. The principle of the slide rule lies in the use of logarithmic scales; addition or subtraction of two lengths is equivalent to multiplication or division, respectively. Because the logarithmic scale has the base 10, decimal points are neglected during most operations; that is, the settings for 0.35, 3.5, and 350 are identical. The user must locate the decimal point correctly at the end of the computations.

The standard slide rule consists of three parts: (1) the body, a fixed section made up of upper and lower halves that are fastened together and marked with various scales; (2) the slide, a movable central section that slides in the middle of the body; and (3) the cursor, a transparent piece that has a vertical marking (the hairline) and can move along the body and the slide to aid in aligning the scales accurately. Because of the accessibility of hand-held electronic calculators, the slide rule has become outmoded.

Slidell, John [sly-del'] John Slidell, b. New York City, 1793, d. July 29, 1871, was an American politician and diplomat. He graduated (1810) from Columbia College and moved (1819) to New Orleans, where he practiced law. A Democrat, he served as a U.S. representative (1843–45) and senator (1853–61). Mexico's refusal to receive him as President James K. Polk's minister helped precipitate the outbreak of the MEXICAN WAR in 1846. Slidell also played an influential role during James Buchanan's presidency. Appointed (1861) Confederate envoy to Paris during the Civil War, Slidell became involved in the TRENT AFFAIR when his Europe-bound ship was seized by U.S. sailors. In January 1862 he arrived in Paris, where he received much sympathy from Napoleon III but did not obtain recognition of the Confederacy. He remained in Europe after the war.

Sligo [sly'-goh] Sligo is a county in the Connacht province in northern Ireland, on the Atlantic Ocean. Its area of 1,795 km^2 (693 mi^2) consists of lowlands traversed by the Ox Mountains. The population is 56,046 (1986); the county town is Sligo (1986 pop. 17,232). Livestock raising, dairying, and salmon fishing are the mainstays of the economy, but tourism is gaining importance. Prehistoric sites in the area include Maeve's Mound, a huge cairn at Knocknarea, and megaliths at Carrowmore. Owned by the MacDermott family until the 12th century, Sligo was subsequently under the rule of the DeBurgos, O'Donnells, and O'Dowds before being chartered as a county in 1579.

Slim, William Joseph, 1st Viscount Slim The British field marshal William Joseph Slim, 1st Viscount Slim, b. Aug. 6, 1891, d. Dec. 14, 1970, commanded (1942–45) the British Army's 1st Burma Corps during World War II. Although unable to prevent the Japanese from overrunning Burma in 1942, he thwarted (1944) their attempted invasion of India and mounted a successful guerrilla-style campaign that eventually forced them out of Burma (1945). Promoted to field marshal in 1948, Slim served as chief of the imperial general staff (1948–52) and governor-general of Australia (1953–60).

slime mold Slime molds are organisms that resemble amoebas in their feeding and reproducing stages but resemble fungi or molds in their fruiting stages. Because of these characteristics, they are classified in various ways in different taxonomic systems. In the five-kingdom system used here, the slime molds constitute the division Myxomycota in the kingdom Fungi (see FUNGI). The best understood are the cellular slime molds (class Acrasiomycetes) and the acellular, or true, slime molds (class Myxomycetes), both of which serve as predators on decomposer organisms. Other classes include the Plasmodiophoromycetes and the Protosteliomycetes.

Cellular slime molds interact with one another during their life cycle to form multicellular aggregates that differentiate into fruiting bodies. The life cycle of *Dictyostelium discoideum* begins when each spore germinates to yield a uninucleate amoeba. The amoebas move by pseudopodia, feed on bacteria, and divide. They stream together when starved, forming centers of aggregation. The aggregated cells form a pseudoplasmodium, or "slug." Slugs up to 1 cm (0.4 in) long migrate, leaving behind a slime sheath. Overhead light or a high concentration of ions stimulates fruiting.

The true slime molds have both microscopic, uninucleate amoebas and macroscopic, multinucleate plasmodia as feeding stages. These slime molds form elaborate spore-containing fruiting bodies, often found on tree bark, dead leaves, or grass. Spores germinate to yield amoebas, which feed on bacteria, divide, and follow one of three developmental pathways. They can differentiate into flagellated swarm cells that later revert to amoebas; if starved, they encyst until food becomes available; and they can differentiate into plasmodia (often a sexual process). Amoebas of two mating types fuse to form a zygote; in some species, a single amoeba may initiate a plasmodium without sexual fusion.

There are three major types of plasmodia. Protoplasmodia split once they contain several hundred nuclei. Aphanoplasmodia lack granules and form a fine network of streaming protoplasm. Phanoplasmodia are granular, contain numberless nuclei, and can grow to a great size; they are often found as a slimy ooze, often bright yellow, in rotting wood. Plasmodia sometimes form sclerotia, which are resistant to drying.

All the nuclei in a plasmodium divide synchronously about every ten hours. Under appropriate conditions—ranging from starvation to the presence of light and appropriate nutrients—plasmodia differentiate into fruiting bodies. In sexual strains, meiosis takes place during fruiting. The fruiting body, often supported by a cellulosic acellular stalk, is covered by a hard peridium that encloses the mass of spores.

Sloan, John [slohn] An early social realist, John Sloan, b. Lock Haven, Pa., Aug. 2, 1871, d. Sept. 7, 1951, painted aspects of the New York City scene in a naturalistic style inspired by 17th-century Dutch genre painting. He began as a newspaper artist for the Philadelphia *Inquirer* (1892) and *Press* (1895), supplying the drawings that then served in place of photographs. He studied with Robert Henri, the leader of a group of young

In 6th Avenue and 30th Street *(1907), by John Sloan, the woman in white contrasts sharply with the somber New York City setting. Sloan used deep perspective and the casual modeling of the Ashcan school. (Private collection.)*

realists opposed to academic standards. Henri encouraged Sloan to paint seriously, and in 1904, Sloan moved to New York, where the artist found creative inspiration in the city's daily life. From about 1900 to 1920, Sloan took part in various innovative exhibits including the show of the Ashcan school (1908), the Exhibition of Independent Artists (1910), and the Armory Show (1913). He was art director of *The Masses* (1912–14), a socialist magazine, as well as a founder and president of the Society of Independent Artists (1918–44). Sloan was a popular teacher at the city's Art Students League (1916–37), where he met his second wife, Helen Farr, with whom he collaborated on the book *The Gist of Art* (1939).

Sloan Foundation The Alfred P. Sloan Foundation, with headquarters in New York City, was established in 1934 by Alfred P. Sloan, Jr., the U.S. industrialist who headed General Motors Corp. in its formative period. The foundation supports programs of research and education in science and technology, medicine, economics and management, and related social areas.

Sloan-Kettering Institute for Cancer Research The Sloan-Kettering Institute for Cancer Research, a research unit of the Memorial Sloan-Kettering Cancer Center, is located in New York City. Created in 1945 by the Sloan Foundation, it conducts research in physical and biological sciences relating to cancer. The Sloan-Kettering Institute also provides graduate instruction through Cornell University.

sloth Tree sloths are five to seven species of slow-moving, leaf-eating, arboreal mammals of the family Bradypodidae and are found principally in the rain forests of Central and South America. Members of the order Edentata, which also includes the anteaters and armadillos, tree sloths are nocturnal, usually solitary animals that spend most of their lives upside down in trees. If forced to the ground a tree sloth must crawl, because its limbs lack the strength to support its body. Algae often grow on a tree sloth's coarse fur, giving the usually brown-gray coat a greenish tinge; three species of moths and certain beetles and mites also may live there. The three-toed sloths, genus *Bradypus*, have three toes on each foot; both species of two-toed sloths, *Choloepus*, have three toes on each hind foot but only two toes on each forefoot.

Tree sloths range from about 50 to 68 cm (20 to 27 in) in length and from 4 to 9 kg (9 to 20 lb) in weight. They have a short, rounded skull; small, rounded ears; and, if present, a stubby tail. Possibly because their body temperature is not constant, varying between 24° and 35° C (75° and 95° F) or more, they require a high environmental temperature.

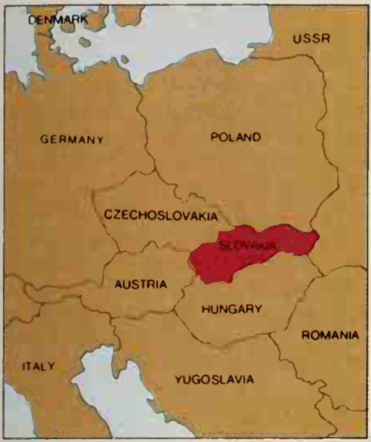
Ground sloths are an extinct group of mammals related to the tree sloths. They first appeared during the late Oligocene Epoch in South America, about 26 million years ago; spread into North America; and became extinct at the end of the Pleistocene, about 10,000 years ago.

The two-toed sloth C. didactyles *is camouflaged by its fur, which has algae growing on it. The algae turns green in rainy weather and yellow during drought, rendering the sloth indistinguishable from surrounding foliage.*

Slovakia [sloh-vah'-kee-uh] The autonomous republic of Slovakia forms the eastern part of Czechoslovakia. It has an area of 48,954 km^2 (18,902 mi^2) and a population of 5,268,935 (1991). Most of the territory is occupied by the western CARPATHIAN MOUNTAINS, whose highest peak, Gerlachovský, rises to 2,655 m (8,711 ft). The lowlands in the south along the Danube River contain the most fertile soil in the country. BRATISLAVA, the capital, and KOŠICE are the republic's major cities.

Industries include engineering and metallurgical plants, hydroelectric-power stations, and chemical factories. Iron-ore mining is also important. Wheat, vegetables, sugar beets, corn, and fruits are grown in the south; oats, potatoes, rye, and flax are planted in the higher regions. Livestock raising, forestry, and dairying complement the economy. Tourism is important in the mountains.

Inhabited by Illyrian, Celtic, and Germanic tribes in the 1st century AD, the region was a part of the Slavic



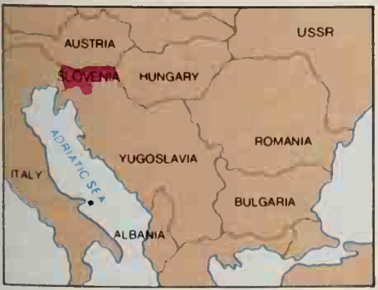
Slovakia is one of the two constituent republics of Czechoslovakia. Before the creation of Czechoslovakia in 1918, Slovakia was part of Hungary for almost a millennium. Major cultural differences exist, therefore, between the Slovaks and the Czechs, who were previously under direct Austrian rule.

empire of Great MORAVIA in the 9th century. In the 11th century Slovakia became a territory of Hungary. A Slovak national revival took place in the 19th century, and in 1918 the Slovaks joined with the Czechs of Bohemia and Moravia to form the independent state of Czechoslovakia. After the Germans established a protectorate over Bohemia and Moravia in March 1939, Slovakia became nominally independent, but its leader, Father Jozef Tiso, placed the country under German protection. In 1945, Slovakia again became a province of Czechoslovakia, and in 1948 it was recognized as a constituent state.

After the overthrow of the Communist regime in 1989, Slovak separatist tendencies reemerged, and in late 1992, Slovak and Czech leaders began to prepare the dissolution of Czechoslovakia.

Slovenia [sloh-vee'-nee-uh] Slovenia, formerly a constituent republic of YUGOSLAVIA, declared its independence in 1991. Bordering Austria, Hungary, Croatia, and Italy, the landlocked country has an area of 20,251 km^2 (7,819 mi^2) and a population of 1,974,839 (1991). The capital is LJUBLJANA, with a population of 323,291 (1991). Mountainous and forested, Slovenia is crossed by the Julian Alps in the west and bordered by the Karawanken Mountains in the north. Agriculture, forestry, and livestock raising form the base of the economy. Slovenia is also highly industrialized. Textiles, cement, and iron and steel are manufactured, and coal and mercury are mined.

Slovenia was settled in the 6th century by the Slovenes, a south Slavic group, but came under Germanic control in the 8th century. Politically attached to the Holy Roman Empire, the region was part of the crownlands of the Habsburg dynasty from the 14th century to 1918. A Slavic national revival took place after 1848, and in 1918, Slovenia became part of the Kingdom of the Serbs, Croats, and Slovenes, which, in 1929, was renamed Yugoslavia. The republic won international recognition as a country in 1992.



The shaded portion of the map indicates the location of Slovenia, the northernmost of the once constituent republics of Yugoslavia.

sludge Sludge is a concentrated suspension of solids in a liquid (usually water) obtained by gravity settlement; further concentration may require a centrifuge, filter, or drier. In water purification, chemical sludges result from the precipitation of flocculants that absorb microorganisms, debris, coloring matters, and other unwanted materials as they settle. Such sludges are waste products that must be concentrated as far as is economically possible before dumping. The purification of municipal sewage produces large quantities of unstable and difficult sludges. Purification in most advanced SEWERAGE systems uses sludge digestion, a process that stores sludge in tanks out of contact with air and heated to about 35° C (95° F). At this temperature bacterial action produces combustible gas, part of which is used to maintain the temperature. Digested sludge is usually dumped in LANDFILLS, or barged or pumped out to ocean dumps—a practice that the Environmental Protection Agency hopes to end soon. Dried and powdered household sludge is an excellent soil builder. Industrial sludge, however, contains metals that make it unsuitable for such use. Methods are being investigated to remove the metals so that it can be used as compost.

slug A diverse group of gastropod MOLLUSKS (class Gastropoda), slugs lack the large external shell that is characteristic of other gastropods. Included in this group are marine forms called sea slugs, or nudibranchs, grouped into the subclass Opisthobranchia. These forms breathe through the epidermis or with the help of respiratory structures. The terrestrial forms (subclass Pulmonata) use a lunglike modification of the mantle cavity for respiration. Internal organs are incorporated into the head-foot and covered by a flap of tissue called the mantle, giving the animals a streamlined appearance. Like the terrestrial snails, slugs have well-developed heads with a concentration (cephalization) of central nervous system ganglia, and tentacles bearing eyes. Terrestrial slugs inhabit wooded, field, or garden areas. They are primarily herbivorous, often doing serious damage to crops, and move on a muscular foot over a mucous trail secreted by

The slug, a gastropod mollusk related to snails, lacks an external shell.

a pedal mucous gland. Sea slugs live in shallow water and usually feed on small animals.

Sluter, Claus [sloo'-tur] Claus Sluter, d. 1405 or 1406, whose background was Dutch, was the greatest and most influential northern European sculptor of the late Middle Ages. His principal works were executed at the Chartreuse de Champmol, the Carthusian monastery near Dijon, founded by Philip the Bold of Burgundy. Sluter's first major project was the monastery portal (1389–97), which he adorned with statues of the duke and duchess, accompanied by Saints John the Baptist and Catherine, kneeling in adoration before the Virgin and Child. Sluter also carved the famous *Well of Moses* (1395–1403) with its 6 over-life-size statues of Old Testament prophets for the Chartreuse. His third major project at the Chartreuse was the *Tomb of Philip the Bold* (now in the Dijon Museum), with its marvelous procession of 40 mourning figures, which was begun in 1384 by Sluter's predecessor, Jean de Marville, and completed in 1410 by Sluter's nephew Claus de Werve.

Discarding traditional medieval formulas, Sluter began a new chapter in the history of sculpture by creating a style of realistic, volumetric figures, swathed in abundant drapery, as elegant as they are naturalistic.

Small Business Administration The Small Business Administration (SBA) was established by the U.S. government in 1953 as an independent agency to aid, counsel, and protect the interests of small businesses. It provides loans for business expansion and improvement and to those small businesses which become victims of natural disasters and civil disorders. The SBA attempts to increase the number of government contracts awarded to small businesses (which since 1976 have included farms) and sponsors programs to develop management skills. Its Minority Small Business program aims at increasing the number of minority owner-operated enterprises; another program promotes the growth of businesses owned by women.

smallpox Smallpox, or variola, was at one time one of the worst scourges ever to afflict humankind, surpassing cholera, bubonic plague, and yellow fever in time span, number of victims, and geographical coverage. The smallpox virus generally was passed from person to person in droplets discharged from the nose and mouth, and it reproduced in lymphoid tissue. It could also be transmitted via dried smallpox scabs and through contact with articles used by a smallpox patient. After a 12-day incubation period, patients usually developed chills, high fever, nausea, aches, and a rash that filled with pus and sometimes swelled severely. Up to 40 percent of the patients died; in the rest, scabs eventually formed and then fell off, leaving permanent pits and scars in the skin. Some patients were left blind.

In 1796 the English surgeon Edward JENNER made a smallpox vaccine from COWPOX serum, which was widely used thereafter; for a patient who contracted smallpox, however, no specific treatment was ever developed. In 1967 the World Health Organization (WHO) began an intensive campaign to wipe out remaining occurrences of the disease, and by mid-1977 smallpox seemed to be eradicated. A few further deaths occurred in 1978, however, when a technical failure permitted the virus to escape from a laboratory in Birmingham, England. As a result, worldwide efforts were made to restrict the number of laboratories holding the virus for research purposes. In October 1979 the world was officially declared smallpox-free by the WHO. The VACCINIA virus used to vaccinate against smallpox is now being used in the development of other vaccines.

Smeaton, John [smee'-tuhn] The English engineer John Smeaton, b. June 8, 1724, d. Oct. 28, 1792, is most noted for his construction (1756–59) of the Eddystone Lighthouse off the coast of Devon, England. With its design of dovetailed stone blocks—still used where structures must survive the pounding of waves—Smeaton's lighthouse stood for almost a century and was taken down only because of the undermining of its rock foundation. In addition to important canal, harbor, and bridge works, Smeaton was active in developing the steam engine. The Smeatonian Club, of which he was founder (1771), was a forerunner of the influential 19th-century Institution of Civil Engineers.

smell see TASTE AND SMELL

smelling salts An aromatic mixture of ammonium carbonate or an ammonia solution and perfume, smelling salts are used to relieve faintness and headaches. When inhaled, the fumes stimulate medullary reflexes in the brain by irritation of the nerve endings in the mucous membranes of the upper respiratory system and the stomach. The reflexes, in turn, stimulate breathing and relieve faintness. Once commonly used, smelling salts are now limited to use mainly in athletics.

smelt Smelts, family Osmeridae, are 10 or 11 species of small, slender, silvery fishes with soft scales and a fatty adipose fin near the tail. In addition to those members commonly called smelt, the family contains the capelin, *Mallotus villosus*, and the eulachon, or candlefish, *Thaleichthys pacificus*. The capelin is found in the Arctic Ocean and northern seas, but smelts are generally distributed in temperate to cold coastal waters of the northern Pacific and Atlantic oceans. (The American smelt, *Osmerus mordax*, and the European smelt, or sparling, *O. eperlanus*, inhabit the Atlantic.) Three species—the capelin, the night smelt, *Spirinchus starksi*, and the whitebait smelt, *Allosmerus elongatus*—are strictly marine; the others spawn in fresh water. Landlocked, freshwater populations of several of the latter species occur widely. Smelts range in size from 10 to 35 cm (4 to 14 in).

smelting see METALLURGY

Smet, Pierre Jean de see DE SMET, PIERRE JEAN

Smetana, Bedřich [smet'-ah-nah, bed'-ur-zhik] The Czech composer Bedřich Smetana, b. Mar. 2, 1824, d. May 12, 1884, was the foremost proponent of Bohemian musical nationalism. Although he was a precocious pianist and composer by age eight, he was given little formal training. Moving frequently with his family, Smetana became familiar with the people and the countryside, both of which became sources of his musical inspiration. After 1843 he lived mostly in Prague, earning a livelihood teaching music and studying composition under Josef Proksch.

In 1856, Smetana moved to Sweden as director of the Göteborg Philharmonic Society but returned to Prague in 1861 to participate in the rejoicing over Bohemia's newly won autonomy (1860) from Austria. He composed the first operas ever to invoke the Bohemian character: *The Brandenburgers in Bohemia* (1863), a moderate success, and *The Bartered Bride* (1866), a triumph that eventually was accepted into the repertory throughout Europe. He also composed six symphonic poems collectively called *Má Vlast* (*My Country*, 1874–79), depicting the glory of Bohemia's landscape and traditions; the most famous of these, *Vltava* (*The Moldau*, 1874), was inspired by one of his country's great rivers. In these works he captures the spirit of his people, using both authentic and stylized folk songs and dances. His best-known chamber work is the autobiographical string quartet *From My Life* (1876). In the 1870s, Smetana suffered increasingly from deafness. By 1882 his general health was bad and his emotional state depressed; two years later he was confined to a mental hospital. At his death he was recognized as a national hero.

Smilodon see SABER-TOOTHED CATS

Smith, Adam Often called the founder of modern economics, Adam Smith, b. Kirkcaldy, Scotland, June 5, 1723, d. July 17, 1790, was a wide-ranging social philosopher and economist whose masterwork, *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776), is one of the most influential studies of Western civilization.

Smith's intellectual interests were extensive. He wrote an important philosophical treatise, *The Theory of Moral Sentiments* (1759), was well versed in science and history, and counted philosopher David Hume and inventor James Watt among his friends. He studied at Glasgow and Oxford universities, lectured at the University of Edinburgh, and in 1751 became a professor at Glasgow University.

Smith's major thesis in the *Wealth of Nations* was that, except for limited functions (defense, justice, certain public works), the state should refrain from interfering with the economic life of a nation (see LAISSEZ-FAIRE). Smith did not view favorably the motives of merchants and businesspeople. "People of the same trade," he wrote, "seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices." He suggested, however, that businesspeople seeking their own interest are led "as if by an invisible hand" to promote the well-being of society.

Adam Smith, a Scottish philosopher and economist, is most widely known for his treatise An Inquiry into the Nature and Causes of the Wealth of Nations *(1776). Smith's exploration of the relationship between government and business had a profound influence on the development of capitalism.*

This position is supported in the *Wealth of Nations* by an elaborate analysis of how economic systems function and develop over time. Smith sought to show how competition in the marketplace would lead businesspeople to supply the goods consumers want, to produce these goods efficiently, and to charge only what they are worth. He further argued that economic growth, which depends upon capital accumulation and an increased division of labor, would be promoted best by private rather than public efforts. People would save and invest for the future because of the inherent desire of individuals to better their own condition. Finally, he sharply criticized the mercantilist writers of his day who advocated state intervention in international trade to achieve an inflow of foreign treasure. Smith claimed, perhaps somewhat unfairly, that MERCANTILISM confused money and wealth, ignoring the fact that the only real purpose of money is to purchase goods. He maintained that FREE TRADE increased the wealth of nations, while restrictions on trade diminished wealth.

Smith, Alfred E. The Democratic politician Alfred Emanuel Smith, b. New York City, Dec. 30, 1873, d. Oct. 4, 1944, was the first Roman Catholic nominated for president of the United States by a major party. He left school after his father's death and took a series of odd jobs. Befriending a local Tammany Hall leader, he entered politics and in 1903 was elected to the New York state assembly.

Smith proved a skilled politician; in 1911 he became the assembly's majority leader. Representing a tenement district of New York City, he was sensitive to the needs of his constituents. As a reformer he was greatly influenced by the city's 1911 Triangle Waist Co. fire, a disaster in which 146 workers, most of them female, lost their lives. Spurred on by Smith, the legislature launched an investigation of factory conditions. Smith worked closely with social reformers and sponsored bills to regulate the wages and hours of women and children, provide increased workers' compensation, and enforce sanitary, health, and fire standards.

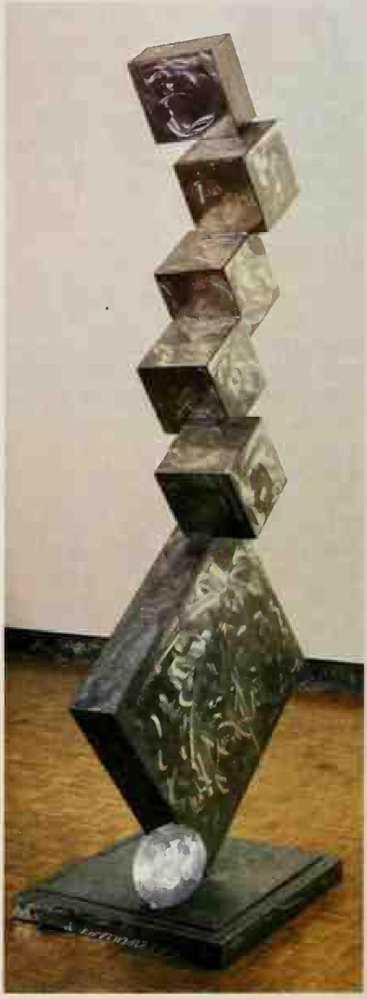
By 1918, Smith had attracted wide popularity and was elected to the first of four terms as governor. He defended civil liberties and attacked prohibition while streamlining the state's bureaucracy and advocating social reforms. In 1924, Smith was a major contender for the Democratic presidential nomination. The convention deadlocked over cultural issues, such as prohibition, however, and neither he nor William G. McAdoo, the favorite of the rural, dry delegates, was endorsed. In 1928, Smith won the nomination, only to encounter bitter opposition from Protestant leaders, prohibitionists, and the Ku Klux Klan. He campaigned aggressively but lost the election to Republican Herbert Hoover. Out of public office, Smith headed the effort to finish the Empire State Building. In the 1930s he became a bitter foe of the New Deal.

Smith, Bessie Known as the "Empress of the Blues," Bessie Smith, b. Chatanooga, Tenn., Apr. 15, 1894, d. Sept. 26, 1937, was the most successful female blues singer of the 1920s. She began her career as a singer in honky-tonks and tent shows, but in 1923 went to New York for her first recording session. She was an immediate sensation, and during the succeeding decade she recorded and toured extensively. She was hearty, forthright, and totally uninhibited in her performance as well as in her life. Because of her impeccable rhythmic sense and her ability to improvise around the structural confines of the blues, Gunther Schuller, in his book *Early Jazz*, calls her the first important jazz singer. The circumstances of her death, in an automobile accident in Mississippi, were the subject of a play by Edward Albee (*The Death of Bessie Smith*, 1960).

Smith, David David Smith, b. Decatur, Ind., Mar. 9, 1906, d. May 23, 1965, one of the most influential American sculptors of the post–World War II era, began his artistic career as a painter. He admired the welded metal sculpture that Pablo Picasso and Julio Gonzalez did in the early 1930s, and this, together with the experience he had gained in metalworking in an automobile factory during his youth, led Smith to explore the medium of welded steel.

The imagery of Smith's early works and others completed as late as 1950 had a strongly biomorphic and surrealist quality, resembling that of the 1930s sculptures by Picasso and Alberto Giacommetti. These early works also have a pronounced two-dimensionality that, with Smith's tendency to use thin steel rods to define areas in a linear manner, gave his work the feeling of having been drawn in space. This quality may be related to his beginnings as a painter. Smith never denied these roots; in fact, one of his concerns was to bring color to sculpture. Much of his work was painted, and the surface of his later sculpture in stainless steel was frequently abraded with a disk grinder to make it reflect light only selectively.

By the late 1950s, Smith's work began to lose its biomorphic quality, becoming more abstract and geometric. His sculptures were frequently done in series to explore the possibilities of a particular form, such as the circle in the *Tank Totem* series (1952–60), the slanted planes in the *Zig* series (1961–63), and the stainless-steel cubes in the *Cubi* series (1963–65). Among his most remarkable works are the 27 sculptures of the *Voltri* series, made in 1962 during a one-month stay in Italy.



In Cubi I *(1963), by the American sculptor David Smith, rectangular steel blocks are welded together in an asymmetrical, vertical construction. The roughened surfaces reflect the light, endowing this abstract geometric form with a totemlike appearance. (Detroit Institute of Arts.)*

Smith, Howard K. Familiar to television audiences as a news analyst and commentator, Howard Kingsbury Smith, b. Ferriday, La., May 12, 1914, worked (1939–57) with CBS in Europe and then in the United States as an anchorman for ABC. At times outspoken, Smith has been involved in several controversies concerning the news reporter's responsibility and is the author of several books about his experiences as a journalist.

Smith, Ian D. Ian Douglas Smith, b. Apr. 8, 1919, led Rhodesia (now Zimbabwe) in its unilateral declaration of independence (UDI) from the United Kingdom in 1965. In 1961, Smith founded the Rhodesian Front party, a white-supremacist organization seeking independence. Smith became prime minister in 1964. After UDI, the ruling white minority suppressed black nationalism. After 12 years of economic sanctions by the international community and mounting guerrilla attacks by nationalist groups led by Robert MUGABE and Joshua NKOMO, Smith agreed (1978) to a restricted form of black majority government. He subsequently served (1979–80) as minister without portfolio in Bishop Abel T. MUZOREWA's government. In 1979, however, UDI was repealed and fresh elections were held (1980). Smith's party (renamed the Republican Front in 1981) won all 20 seats allotted to whites in parliament. Smith was accused of supporting apartheid and banned from parliament in 1987.

Smith, Jedediah Strong Jedediah Strong Smith, b. Chenango County, N.Y., Jan. 6, 1799, d. May 27, 1831, was a leader of the MOUNTAIN MEN of the western fur trade and an explorer of the American West. A member of Gen. William H. ASHLEY's party in 1822—the first large group of trappers to travel to the mountain region—Smith quickly rose to the status of captain in the trapper brigades, became a partner in one of the most important of the early fur companies in the Rockies, and, between 1822 and 1831, traveled extensively throughout the West. He discovered (1824) the South Pass, a gateway to the Far West; pioneered (1826–27) the overland route to California through the Great Basin and the Sierra Nevadas; and opened (1828) the overland trail from California to the Columbia River.

Smith's most remarkable journey began in July 1827 when he and a party of trappers left the fur-trade rendezvous in Cache Valley, Utah, and traveled southwest to California across the Great Basin and Mojave Desert, following a trail blazed by Smith the year before. Moving north through the California mountains, Smith reached the Willamette Valley, Oreg., in July 1828, and the Columbia River in August. In March 1829 he traveled east across the mountains to the Flathead River of Montana and then south to conclude the trek at Pierre's Hole, Idaho, in August. Two years later he was killed by Comanche Indians while leading a wagon train to Santa Fe, N.Mex.

Smith, John A colorful and effective leader, John Smith, b. *c.*1579, d. June 21, 1631, helped establish the first permanent English colony in North America at JAMESTOWN, Va. Smith joined the LONDON COMPANY in 1606 after spending about five years fighting the Turks in Hungary and Transylvania. He was among the 105 settlers who disembarked at Jamestown in May 1607, and he soon became a pivotal figure in the enterprise.

While exploring (December 1607) the Chickahominy River, Smith was captured by Algonquian Indians and taken to their chief, POWHATAN. Although the precise details of their encounter remain clouded in myth, it appears that Smith was saved from execution by Powhatan's 13-year-old daughter POCAHONTAS, who later facilitated Smith's initiation into the tribe. By the autumn of 1608, Smith had been elected president of the governing council of Virginia and was instrumental in securing corn from the Indians for the starving settlers. Smith left Virginia in October 1609. Five years later he became active in the initial exploration of New England. His *Description of New England* (1616) stands alongside his *Map of Virginia* (1612) and *General Historie of Virginia* (1624) as important documents chronicling the early history of English colonization in North America.

Smith, Joseph Joseph Smith, b. Sharon, Vt., Dec. 23, 1805, d. 1844, was the founder, prophet, and first president of the Church of Jesus Christ of Latter-day Saints (see MORMONISM). When he was 10 years old, his family moved to Palmyra, N.Y. Four years later Smith experienced a vision of God and Jesus Christ, who instructed him not to join existing churches. About 1827, in another vision, a heavenly messenger directed him to some gold plates inscribed with hieroglyphics. Smith translated and published (1830) the text as the *Book of Mormon*. In it he tells the religious history of an ancient people who lived on the North American continent and whom he describes as descendants of the ancient Hebrews.

In 1830, Smith organized the Church of Jesus Christ of Latter-day Saints and immediately began to send out missionaries. Because of the conversion of a large number of people in Ohio, he moved to Kirtland, Ohio, and built a temple. He then founded another community in Jackson County, Mo. Conflict with the non-Mormon population in Missouri caused the Mormons to be driven from Jackson County to northern Missouri. In 1837 persecution forced Smith to flee Kirtland for Missouri. Within a few months of his arrival, however, his people were driven out and he was put in jail. After several months his jailers allowed Smith to escape, and he fled to Illinois, where the Mormons were gathering. Smith helped to found (1839) the city of Nauvoo on the Mississippi.

The Mormon prophet preached the gathering of the religious into one area and the eternal progress of humankind. In Nauvoo, Smith reached the high point of his career. The people of Illinois welcomed the persecuted Mormons, and Smith began the construction of a temple

Joseph Smith, the founder of Mormonism, was lynched by a mob in Carthage, Ill., in 1844. Most of his disciples then followed Brigham Young to Utah. Of those who remained, the majority formed (1852) the Reorganized Church of Jesus Christ of Latter-day Saints under the presidency of Smith's son Joseph Smith III.

and a hotel. The state of Illinois gave the new city a charter that allowed for a militia called the Nauvoo Legion, with Smith as the commanding general. Later he also served as the mayor of Nauvoo, and in 1844 he announced his candidacy for the U.S. presidency.

In 1843, Smith had secretly instituted the practice of plural marriage among a select group. Because of rumors of polygamy (he himself was alleged to have as many as 50 wives) and because of jealousy over the Mormons' prosperity in Nauvoo, persecution increased. When the city council ordered the press of *The Nauvoo Expositor*—a dissident newspaper—destroyed, Smith and his brother Hyrum were arrested and taken to Carthage, the county seat. On June 27, 1844, both were shot and killed by a mob.

Smith, Kate Kathryn Elizabeth Smith, b. Greenville, Va., May 1, 1909, d. June 17, 1986, was an enormously popular American singer. First appearing in a Broadway revue in 1926, she launched a regular radio program in 1931 with her theme song, "When the Moon Comes over the Mountain." She introduced (1938) "God Bless America," which Irving Berlin wrote for her.

Smith, Margaret Chase Margaret Chase Smith, b. Skowhegan, Maine, Dec. 14, 1897, was the first woman to serve both in the United States House of Representatives (1940–49) and in the Senate (1949–73). A Republican from Maine, whose husband, Clyde Smith, preceded her as U.S. representative, she was noted for her conscientious attendance on the Senate floor during debates and votes. She worked as a teacher and on her hometown weekly newspaper before entering politics.

Smith, Oliver The American scenic designer and producer Oliver Smith, b. Waupun, Wis., Feb. 13, 1918, is renowned for his versatility and for the evocative quality of his settings. After college he began a lifelong association with American Ballet Theatre, of which he was codirector (1945–80) with Lucia Chase. His most notable work there includes *Rodeo* (1942), *Fall River Legend* (1948), and *Les Noces* (1965). Smith's extensive Broadway career began with *On the Town* (1945) and ranges from *My Fair Lady* (1956) to *Night of the Iguana* (1962).

Smith, Red Only the second sportswriter ever to receive (1976) a Pulitzer Prize, Walter Wellesley "Red" Smith, b. Green Bay, Wis., Sept. 25, 1905, d. Jan. 15, 1982, was considered the heir to Grantland Rice as dean of American sportswriters. Smith worked for five newspapers—last for the *New York Times* (1971–82)—and was, from 1954, the most widely syndicated U.S. sports columnist. Although versatile, Smith preferred to write about baseball, football, boxing, and horse racing.

Smith, Sydney Primarily remembered as a wit and polemical writer, the 19th-century English writer Sydney Smith, b. June 3, 1771, d. Feb. 22, 1845, achieved recognition as a clever conversationalist and as a trenchant advocate of liberalism in essays and pamphlets that explored such topics as the political emancipation of Catholics in England. After graduation from Oxford, Smith was ordained (1794) in the Church of England. He lived as a private tutor in Edinburgh and, with Francis Jeffrey and Henry Brougham, founded (1802) the quarterly *Edinburgh Review*. After 1803 he supported himself in London as a preacher, lecturer, and essayist.

Smith, Tony The American sculptor Tony Smith, b. South Orange, N.J., 1912, d. Dec. 26, 1980, was noted for his massive, multiangled structures of paint-blackened steel. Smith began his career as an architect after having studied at the Art Students League in New York City (1933–36) and the New Bauhaus in Chicago (1937–38). For a time, during the late 1930s, he was an assistant to Frank Lloyd Wright. His interest in sculpture, however—begun in art school—continued to develop, and in 1960 he gave up architecture altogether. Much of Smith's sculpture, which has been linked with the MINIMAL ART movement, reveals a fascination with large-scale, space-framing configurations and with the module (or repeated unit of form), as in his towering, latticelike construction entitled *Smoke* (1967; Fishbach Gallery, New York City).

Smith, Walter Bedell Walter Bedell Smith, b. Indianapolis, Ind., Oct. 5, 1895, d. Aug. 9, 1961, was an American general who served (1942–45) as chief of staff to Gen. Dwight D. Eisenhower. After World War II, Smith was ambassador to the USSR (1946–49), director of the Central Intelligence Agency (1950–53), and undersecretary of state (1953–54).

Smith, William The English engineer, geologist, and surveyor William Smith, b. Mar. 23, 1769, d. Aug. 28, 1839, made the revolutionary discovery that fossils can be used to identify the succession of layers or strata of rocks. He is commonly referred to as the founder of English geology.

Smith's work as a surveyor of canals and as a civil engineer allowed him to gather information on strata and to collect fossils. In 1795 he discovered that strata composed of similar rocks could be distinguished by the fossils contained within the strata, and in 1851 he published the first geologic map, *A Map of the Strata of England and Wales, with part of Scotland.* In addition to geological maps and sections, he published (1815–20) several small volumes on the identification of strata by fossils. In honor of his discoveries, Smith received (1831) the first Wollaston Medal of the Geological Society of London and later a pension from the British government.

Independently of Nicolaus Steno and other geologists who had previously recognized the fact, Smith discovered a regular succession of strata in the sedimentary rocks of England. He recognized that the fossil content of strata could be used to distinguish strata that were otherwise similar in composition and appearance. Smith did not study fossils as a part of biology, but merely as a means of identifying and distinguishing strata.

Smith, William Robertson A Scottish biblical scholar, William Robertson Smith, b. Nov. 8, 1846, d. Mar. 31, 1894, was also a student of comparative religion and an encyclopedist. When he introduced current European biblical scholarship into articles written for the ninth edition of *The Encyclopaedia Britannica* (1875), authorities of the Free Church of Scotland objected and removed (1881) him from his professorship at the Free Church College in Aberdeen. Soon thereafter he became an editor of *The Encyclopaedia Britannica* and in 1887 editor in chief. Smith was professor of Arabic at Cambridge University from 1883.

Smith Act The apprehension of the United States over Germany's aggression in Europe during World War II and over alleged Communist-triggered strikes aimed at crippling defense production led to the enactment of the Smith Act (June 28, 1940), also called the Alien Registration Act. The Smith Act required the fingerprinting and registering of all aliens residing in the United States and made it a crime to advocate or teach the violent overthrow of the U.S. government or to belong to a group advocating or teaching it. Many individuals and groups believed that the act violated the 1st Amendment guarantee of freedom of speech, but in 1951 the U.S. Supreme Court upheld its constitutionality in a famous case involving 11 convicted Communists (*Dennis* v. *United States*). In 1957, however, the Court modified its position (*Yates* v. *United States*) and ruled that teaching communism or other revolutionary theories did not in itself constitute grounds for conviction; only proof that direct action had been urged to topple the government could result in conviction.

Smith College Established in 1875, Smith College is a private 4-year liberal arts school for women in Northampton, Mass. One of the SEVEN SISTERS COLLEGES, it participates in a cooperative program with Amherst, Hampshire, and Mount Holyoke colleges and the University of Massachusetts, sharing faculties and facilities. Smith's graduate program and the School of Social Work are coeducational.

Smithson, James James Louis Macie Smithson, b. *c.*1765, d. June 27, 1829, was an English chemist and mineralogist who left a substantial sum in his will to found the SMITHSONIAN INSTITUTION in Washington, D.C. Smithson graduated from Pembroke College, Oxford, and became (1787) a fellow of the Royal Society. He inherited his fortune on his mother's death in 1800. His achievements as a chemist include the analysis of zinc ores, determining that they consisted mostly of zinc carbonate. This substance was later named smithsonite.

Smithson, Robert One of the originators of EARTHWORKS art, Robert Smithson, b. Passaic, N.J., Jan. 2, 1938, d. July 20, 1973, studied at the Art Students League in New York City. In his early work Smithson experimented with minimal and conceptual art, but in 1967 he turned to enormous outdoor projects, which he termed *earthworks.* Smithson's most famous earthwork, *Spiral Jetty* (1970), was a road 4.6 m (15 ft) wide spiraling out into Great Salt Lake in Utah. Companion works were his conical *Spiral Hill* (1971) and his 43-m (140-ft) half-submerged *Broken Circle* (1972), both near Emmen, Netherlands.

Smithsonian Institution The Smithsonian Institution is a collection of scientific and cultural institutes, most of which are in Washington, D.C. It was created by an act of the U.S. Congress in 1846 from the bequest by the British scientist James SMITHSON for "an establishment for the increase and diffusion of knowledge among men." It is governed by a board of regents that includes the vice-president, chief justice, three senators, and three representatives. The Smithsonian consists of the Cooper-Hewitt Museum (in New York City), the Joseph H. Hirshhorn Museum and Sculpture Garden, the Arthur M. Sackler Gallery (of Asian Art), the National Museum of African Art, the National Air and Space Museum, the National Museum of American Art (formerly the National Collection of Fine Arts), the National Museum of American History, the National Portrait Gallery, the National Zoological Park, the Freer Gallery of Art, the National Museum of Natural History, the Smithsonian Tropical Research Institute (in Panama), and other bureaus. The John F. KENNEDY CENTER FOR THE PERFORMING ARTS, the Woodrow Wilson International Center for Scholars, and the NATIONAL GALLERY OF ART are administered separately. A new Indian museum is planned, following a 1988 agreement that would allow liberal borrowing from New York's Museum of the American Indian. The Smithsonian publishes the monthly *Smithsonian* and many scientific and scholarly journals.

smog see POLLUTION, ENVIRONMENTAL

Smohalla [smoh-hal'-uh] The American Indian prophet Smohalla, *c.*1815–1907, was a member of the Wanapam Indians of the Columbia River valley. Smohalla became a warrior and raider. Wounded and left for dead in an encounter with a SALISH war party, he later claimed to have died and spent many months in the afterworld before being restored to life. He brought back a message, believed by his people to be authenticated by his death-and-resurrection experience, that aboriginal lifeways could be restored. The message came at a time of Indian suffering in the Northwest, caused by population decline resulting from white-introduced diseases, and the taking of Indian lands by white settlers. Smohalla joined an existing religious movement, the Dream Dancers, which combined Northwest Indian spirit possession and visions induced by dance with Christian concepts and symbols. Smohalla added the concept that by dancing and receiving visions the Indians could cause the disappearance of whites and could once more prevail in their land. Like the original GHOST DANCE, Smohalla's cult called for divine intercession, not violence.

smoke The word *smoke* refers popularly to all visible air contaminants that arise from COMBUSTION and includes vapors, gases, and particles. More technically, smoke is an AEROSOL (see also COLLOIDAL STATE) of very small particles of both liquid vapors and solid material suspended in air. Smoke is distinguished from dusts, which comprise larger-diameter solid particles, and mists, which are larger-diameter liquid droplets. Smoke is also distinguished from the invisible gases such as carbon monoxide, sulfur dioxide, and gaseous hydrocarbons that also accompany combustion.

Health Hazards. Smoke has always been the major contributor to the air pollution of cities (see POLLUTION, ENVIRONMENTAL). The small particulates of smoke cause adverse health effects, particularly to the respiratory system. Long-term exposure to such contaminated air can result in respiratory diseases such as bronchitis and lung cancer. Over shorter periods smoke can aggravate asthma, bronchitis, emphysema, and cardiovascular ailments.

The effects of smoke particles on health are greatly increased when combined with toxic sulfur dioxide. Most of the water-soluble sulfur dioxide, when inhaled, dissolves in the moisture of the mouth and throat. In the presence of small particles, however, sulfur dioxide can "ride" the particles into the deeper recesses of the lungs. The "killer" smog episodes in London in the 1950s, New York in 1966, and Donora, Pa., in 1948 resulted from combined high levels of smoke and sulfur dioxide. Smoke can also have an adverse effect on materials and vegetation (see ACID RAIN).

Smoke Control. Only recently have governments tried to regulate smoke emissions. London, which had been plagued by smoke pollution for more than 300 years, enacted its first regulations only after a 1952 episode of "killer" smog. Most smoke reductions are accomplished by a shift from the use of coal to cleaner fuels such as oil and natural gas and by the use of various control devices to remove particulates from exhaust gases.

Several different types of control devices have been used to reduce emissions of smoke from large industrial sources. The most efficient for the removal of small particles are scrubbers, electrostatic precipitators, and baghouses.

See also: POLLUTION CONTROL.

smoke detector Used for FIRE PREVENTION AND CONTROL, a smoke detector is a small device designed to emit an audible warning at the first sign of smoke. The two principal types are photoelectric, or optical, and ionization. Photoelectric detectors are activated when smoke obscures or scatters a beam of light, causing a change in the flow of electrical current (see PHOTOELECTRIC CELL). Ionization devices are activated when smoke particles attach themselves to ions created in the detector by a minute radioactive source, thus reducing the flow of current. Each type of detector can be powered by house current or batteries.

Detectors are most effective when installed on the ceiling or high on a wall, away from air vents. In the home, primary locations should be just outside each bedroom area; detectors also should be placed on each additional story and in the basement.

smoking Smoking most commonly refers to the practice of inhaling smoke from the burning TOBACCO in a pipe, cigar, or cigarette. American Indians smoked pipes, and European explorers had introduced the practice into the Old World by the early 16th century. Controversy over the health effects of smoking has existed since that time. Cigarette smoke consists of more than 4,700 compounds, 43 of which are carcinogens, such as tar. NICOTINE, a poisonous ALKALOID, is considered the addicting agent that makes quitting smoking so difficult.

By the early 1960s numerous clinical and laboratory studies on smoking and disease had been made. In 1964 a committee appointed by the surgeon general of the U.S. Public Health Service issued a report based on the critical review of previous studies on the effects of smoking. The report concluded that nearly all lung-cancer deaths are caused by cigarette smoking, which was also held responsible for many deaths and much disability from various illnesses such as chronic bronchitis, emphysema, and cardiovascular disease. A more recent study estimated that about 400,000 Americans die each year from breathing their own smoke.

A 1984 report by the service also suggested that passive inhalation of smoke by nonsmokers could be harmful. Although considered controversial at the time, studies have since confirmed these charges. Some experts estimate that passive smoke kills as many as 50,000 Americans a year, and it is the third leading preventable cause of death, behind smoking and alcohol. Studies have shown that children are particularly sensitive to passive smoke and that pregnant women who smoke may harm the fetus.

Since 1964, health warnings have been mandated on tobacco advertising, and the use of such advertising has been restricted. Most states in the United States have also passed laws to control smoking in public places such as restaurants and workplaces, where nonsmoking areas may be required. U.S. airlines have prohibited smoking on flights lasting six hours or less. Among the military, the U.S. Army has been particularly strict in imposing smoking restrictions. The tobacco industry and many smokers regard antismoking measures as harassment, whereas many nonsmokers defend the measures on the grounds that the government has a duty to discourage unhealthful practices, that public funds in one form or another become involved in treating diseases caused by smoking, and that smokers pollute the air for nonsmokers.

Smolensk [smuhl-ensk'] Smolensk is the capital of Smolensk oblast in the Russian republic of the USSR. It is situated on the upper reaches of the DNEPR RIVER and on the main railroad and highway between Moscow and Warsaw. The population is 341,000 (1989). Smolensk has some light manufacturing industries, including a large linen mill and machinery plants, but has been largely bypassed by modern Soviet industrialization. One of Russia's oldest cities, Smolensk has several churches, built in the 12th century and now restored as museums, and a kremlin, or walled fortress, built about 1600.

Smolensk was first mentioned by Russian historical chronicles in 862. The seat of a Russian principality in the 11th century, it passed to Lithuania in 1408 and to the unified Russian state in 1514. Although occupied by the Poles from 1611 to 1654, Smolensk flourished as a trading and craft-industries center in the 16th and 17th centuries. A major battle was fought nearby in 1812 during Napoleon's invasion of Russia. After railroad arrival (1870s), Smolensk became a transport hub. A strategic center, the city was sharply contested in World War II during the German invasion.

Smollett, Tobias [smahl'-it] Best known for his epistolary novel *The Expedition of Humphry Clinker* (1771), which describes the travels of a family through England and Scotland, Tobias George Smollett, b. Scotland, 1721, d. Sept. 17, 1771, wrote a number of comic and PICARESQUE NOVELS whose inventiveness and wit have earned him a place among the mid-18th-century masters of English fiction. Both the vigor of his satire and the exaggerated eccentricities of his characters influenced later novelists, particularly Charles Dickens. After studying medicine at Glasgow University, Smollett went to London, hoping to become a playwright. With the rejection of his tragedy *The Regicide*, however, he joined the navy as a surgeon's mate and served in the war against Spain. His first novel, *Roderick Random* (1748), a lusty, often brutally satiric account of life in London and also of abuses in the Royal Navy, written while Smollett was still practicing medicine, was based on his own earlier experiences. It was followed by three other episodic novels in a similar vein—*Peregrine Pickle* (1751), *Ferdinand Count Fathom* (1753), and *Sir Launcelot Greaves* (1760–62)—and a political satire, *The History and Adventures of an Atom* (1769).

A prodigiously busy editor, translator, and compiler of reference works, Smollett left for Europe to improve his health in 1763; a satirical account of his two-year journey appeared in *Travels through France and Italy* (1766).

Smoot, Reed Reed Smoot, b. Salt Lake City, Utah, Jan. 10, 1862, d. Feb. 9, 1941, was a Mormon leader and U.S. senator best known as the cosponsor of the Hawley-Smoot Tariff Act of 1930 (see TARIFF ACTS). As a senator (1903–33), Smoot opposed U.S. membership in the League of Nations and was a leader of the conservative Republicans. The Hawley-Smoot Act raised U.S. tariffs to an all-time high, triggering a worldwide reaction and greatly exacerbating the Depression of the 1930s.

smuggling Smuggling is the taking into a country of goods for which customs duties have not been paid; it also refers to the import or export of prohibited goods (including persons). In Europe during the 17th and 18th centuries widespread smuggling arose to avoid TARIFFS and other mercantilistic restrictions. The restrictive British NAVIGATION ACTS resulted in extensive smuggling in the American colonies; the attempt by the British to stop this smuggling was one of the factors in the outbreak of the American Revolution. The British wars with France during the 18th and early 19th centuries and the ensuing BLOCKADES also resulted in much smuggling. England had passed legislation against smuggling as early as the 14th century, but advocates of LAISSEZ-FAIRE such as Adam Smith have defended it. With Britain's (and other countries') adoption of FREE TRADE policies, smuggling declined during the 19th century.

In the United States, liquor smuggling on a huge scale flourished during the prohibition era (1919–33). In the 1980s well-established international drug-smuggling networks provoked worldwide concern. In the United States the Coast Guard is charged with the prevention of smuggling, aided by the U.S. Customs Service and other federal agencies.

smut see DISEASES, PLANT

Smuts, Jan Jan Christiaan Smuts, b. May 24, 1870, d. Sept. 11, 1950, was a South African statesman, philosopher, and general. He studied at Stellenbosch and later had a brilliant career in law at Cambridge, England. In 1898, Smuts, an Afrikaner (or Boer) by birth, was appointed state attorney of the Transvaal by President Paul Kruger. During the South African War (1899– 1902), Smuts led an unsuccessful Boer invasion of the British Cape Colony in April 1902. He participated in the peace talks at Vereeniging (1902), becoming a strong advocate of Anglo-Boer reconciliation. In 1905, Smuts, together with Louis Botha, formed a moderate party, *Het Volk*. Smuts took an active part in the formation of the Union of South Africa (1910) and subsequently served as minister of the interior and mines (1910–12) and as minister of defense (1910–19). He put down a pro-German Afrikaner rebellion in 1914 and two years later assumed command of the Allied forces operating against the Germans in East Africa. In 1917, Smuts accepted a seat on the British war cabinet. He represented South Africa at the Versailles peace conference (1919) and helped to form the League of Nations. Smuts played a major part in the transformation of the British Empire into the Commonwealth of Nations and had a crucial role in the postwar Anglo-Irish peace negotiations.

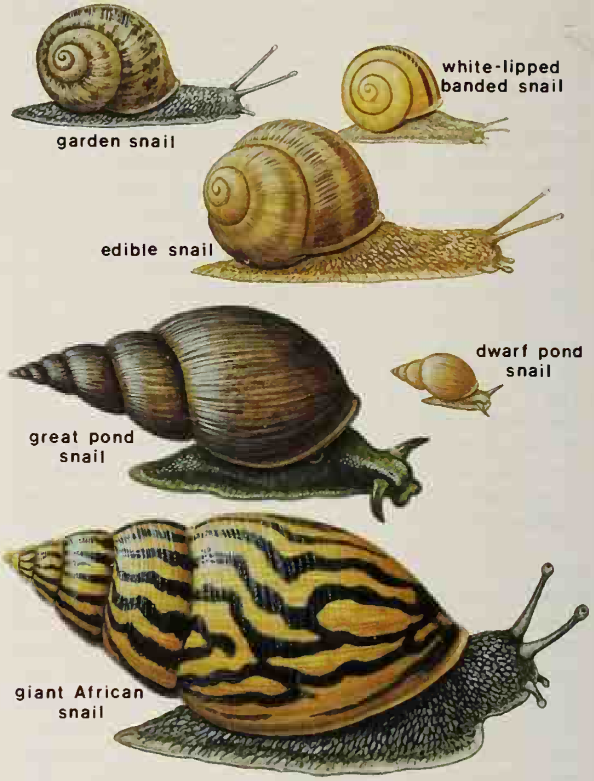
In 1919, Smuts succeeded Botha as prime minister of South Africa, pursuing a proimperial and probusiness policy. He smashed an armed revolt (1922) of white miners on the Witwatersrand but failed to secure Southern Rhodesia's adherence to the Union of South Africa. Defeated in 1924 by a coalition of the Nationalist and Labour parties headed by James Hertzog, Smuts became parliamentary leader of the opposition. In 1933, Smuts joined forces with Hertzog against the more extreme Afrikaner nationalists, serving as minister of justice. As war with Nazi Germany approached, Hertzog resigned, and in 1939, Smuts became prime minister.

South Africa declared war on Germany and gave economic help to Great Britain; South African forces participated in campaigns in East Africa, North Africa, and Italy. At home, Smuts took an increasingly liberal stand and began to question some long-established policies of racial segregation. Smuts represented South Africa at the San Francisco conference (1945) that drafted the Charter of the United Nations. In the general elections of 1948, Smuts's United party was defeated by the opposing National party.

Smyrna SEE İZMIR

Smyth, John [smith] Reputed founder of the English Baptist church, John Smyth, *c.*1554–1612, was educated at Cambridge and became a Puritan preacher and then a separatist pastor at Gainsborough (1606). Taking his followers to Amsterdam in 1608 to escape persecution, he adopted a position favoring adult baptism. After baptizing himself, he established (1609) the first modern Baptist church (1609).

snail Snails represent a large and varied group of shelled gastropod MOLLUSKS in the class Gastropoda. They are diverse in size and ecologically, being terrestrial, freshwater, or marine. One terrestrial species, *Helix pomatia*, is the edible snail (escargot) familiar in French gourmet cooking.



The garden snail and the white-lipped banded snail are two varieties of Cepaea hortensis, *found in Europe and New England, which varies widely in shell color and banding pattern. The edible snail, or escargot, is a gourmet delicacy. The great pond snail reaches about 5 cm (2 in) in length. The dwarf pond snail acts as intermediate host for the sheep liver fluke. The giant African snail is a major agricultural pest in parts of Africa and Asia.*

Externally, snails are characterized by a spiral shell, flattened foot, and anterior head with prominent tentacles. When disturbed, the snail can withdraw into its shell, and in some cases the shell opening can be closed by a horny, or calcareous, plate called an operculum. Locomotion in snails is usually achieved by means of waves of contraction along the bottom of the muscular foot, from rear to front.

All snails undergo body torsion during development. Snails begin development as bilaterally symmetrical animals. During the larval stage the visceral mass is twisted 180 degrees, so that posterior structures such as the anus are brought forward, toward the mouth. Several advantages are thought to accompany body torsion. First, the shell opening is rotated anteriorally, and consequently the snail withdraws into the shell headfirst, providing added protection for that end, which contains concentrated sensory structures and the major part of the central nervous system. In addition, the gills used for respiration (in most species) are rotated anteriorally, and the snail can utilize the undisturbed water ahead of its own path of movement for inhalant respiratory currents. As a result of torsion, the mantle tissue is also rotated anteriorally, adding its sensory organs to those of the head and allowing the snail to monitor more accurately the environment.

The spirally coiled shells of snails contain the visceral mass and most internal organs. The majority of snail shells are coiled to the right, with an accompanying tendency for reduction of the right-hand organs within the visceral mass.

Snails are largely herbivorous, and terrestrial species are of major economic importance as garden and crop pests.

snake The elongated, limbless reptiles known as snakes have long been held in fear and awe by humans and have often appeared in art and mythology. Although some species are dangerously venomous, snakes are important in nature and to humans as predators of rodents. The estimated 2,500 to 3,000 species of living snakes are widely distributed throughout the world. They are most common in warm areas and reach their greatest abundance in the tropics, but the common Old World viper, or adder, *Vipera berus*, occurs above the Arctic Circle (68° north latitude) in Scandinavia and is also found in southern Siberia, and a pit viper called the snouted lancehead, *Bothrops ammodytoides*, is found almost to the southern tip of South America (50° south latitude). Snakes may live at greatly diverse elevations: the sidewinder, *Crotalus cerastes*, for example, occurs in valleys below sea level, whereas the Himalayan pit viper, *Agkistrodon himalayanus*, has been found at 4,800 m (16,000 ft). Snakes live in almost every habitat exclusive of the deep seas and regions of perpetual snow. Some dwell in burrows beneath the ground; others live most of their lives in trees. Snakes may be found in both humid forests and dry deserts, and some sea-inhabiting snakes are completely marine, never leaving the sea, even to reproduce.

The smallest snakes are the slender blind snakes, family Leptotyphlopidae; the adult Texas slender blind snake, *Leptotyphlops dulcis*, for example, may be only 13 cm (5 in) long. According to verified reports, the world's largest snake is the Asiatic reticulated python, *Python reticulatus*, which has attained a recorded length of 10 m (33 ft).

Physical Characteristics

Snakes lack limbs, a sternum (breastbone), a shoulder girdle (skeletal elements for support of the front limbs), external ear openings, and a urinary bladder. In addition, the pelvic girdle (skeletal elements for support of the hind limbs) is absent in most snakes.

Snakes also lack internal mechanisms for maintaining body heat and therefore have variable body temperatures (poikilothermy). Body temperature may be controlled behaviorly, however, by moving in and out of the Sun's rays. Metabolism varies greatly with body temperature. Temperate-zone snakes are subjected to potentially fatal low winter temperatures. Such snakes hibernate, finding shelter in deep underground burrows or crevices, where they remain inactive and their metabolism slows dramatically. Conversely, some snakes may estivate in deep, cool, subterranean recesses during excessively hot and dry periods.

Skull. Partly as an adaptation to permit the swallowing of large food items whole, the snake's skull has been increasingly modified for greater elasticity. In many evolutionarily advanced snakes the only solid portion of the skull is the braincase, the upper skull consisting broadly of the braincase in the rear; small protective bones around the eyes and snout in front; and four rather long tooth-bearing bones below. All four tooth-bearing bones are loosely attached to the skull by elastic ligaments and are independently movable. The bones of the snout are also movable and allow the snake to bend its snout upward.

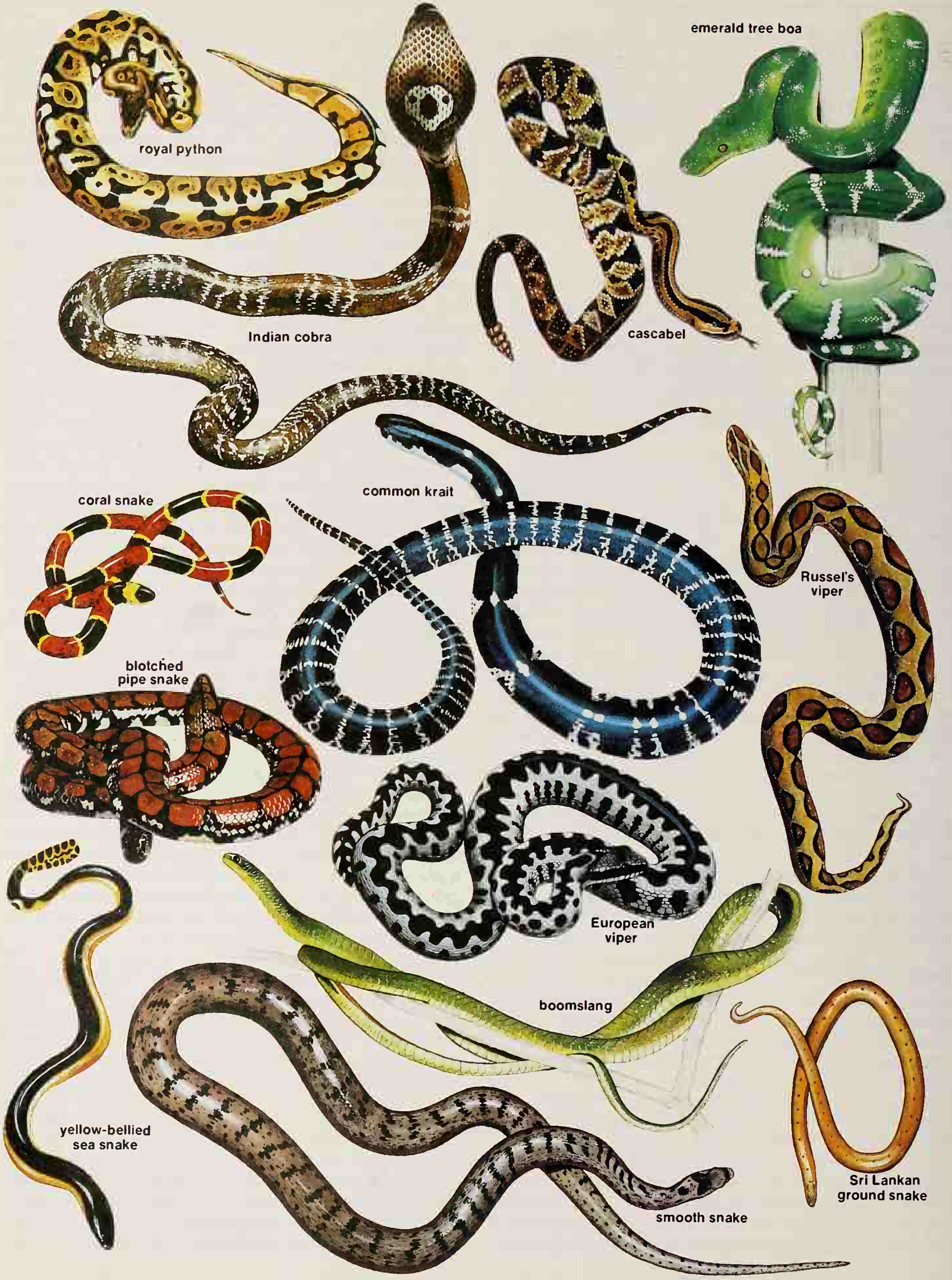
Each side of the lower jaw bears a row of teeth on the forward-positioned dentary bone, and each half of the lower jaw is slightly movable along the line formed between the dentary bone and the rear segments of the jaw. Further, the two halves of the lower jaw are not rigidly fused where they meet in front; rather, they are united only by elastic ligaments that permit the two halves to be rotated or moved apart.

Eyes. Except for the blind snakes, families Typhlopidae, Anomalepidae, and Leptotyphlopidae, whose rudimentary eyes are situated beneath the head scales, a snake's eyes are permanently covered and protected by the transparent lower eyelid. The lower eyelid is fused to the vestigial upper eyelid; snakes, therefore, cannot blink or "close" their eyes. The lenses of a snake's eyes are rounded and are normally adjusted for distance vision. To focus on near objects, the snake moves the lenses forward. Although the eyes are normally set for distance, a snake's distance vision is typically poor except for detecting movement.

Hearing. Snakes lack external ear openings, eardrums, and middle-ear cavities. The small, sound-conducting columella bone, however, is present. When the snake's head is on the ground, earthborne vibrations (sounds) are picked up by the lower jaw and skull and are transmitted by bone conduction to the columella and through the columella to the inner ear. Certain experiments have shown that the snake's inner ear, as well as specialized nerve endings in the skin, can detect low-frequency airborne vibrations.

Jacobson's Organ. The Jacobson's, or vomeronasal, organ is located in front of the roof of the mouth. It is a chemical receptor capable of detecting tiny chemical particles, including those given off in the body scent of animals. The snake's forked tongue is flicked out to allow the chemical particles in the air to adhere to or dissolve in the moisture on the tongue. The tongue is then brought back to the Jacobson's organ, where its forked tip is inserted into the organ's two openings and the chemical particles identified.

Heat Detection. Snakes can detect heat, or infrared, rays through specialized groups of nerve endings scattered through the skin. These heat receptors are presumably involved in sun basking and other thermoregulatory behaviors. More-specialized heat receptors are present as pits along the upper lip margins of many pythons and boas. In the PIT VIPERS, such as the rattlesnakes, the spe-


royal python
Indian cobra
cascabel
emerald tree boa
coral snake
common krait
Russel's viper
blotched pipe snake
European viper
boomslang
yellow-bellied sea snake
Sri Lankan ground snake
smooth snake

(Facing page) *The royal python and emerald tree boa are constrictors. Elapids include the Indian cobra, coral snake, and common krait. Viperids include the cascabel, Russell's viper, and European viper. The yellow-bellied sea snake inhabits Indo-Pacific waters. The blotched pipe snake is a burrowing Asian species. Colubrids include the boomslang, Sri Lankan ground snake, and smooth snake.*

cialized heat receptors (here called pit organs) are highly developed and occur as a single pair at the front of the head. The paired frontal placement of the pit organs enables the rattlesnake not only to detect the presence of warm-bodied prey in the dark but also to strike at it accurately up to a distance of about 50 cm (20 in).

Respiration. In snakes the left lung is either reduced in size or completely lacking. Only the boas and pythons, family Boidae, and the sunbeam snake, family Xenopeltidae, have retained fully functional left lungs. The right lung is a greatly elongated structure and ends in a sac believed to serve for the storage of air. Some snakes also have a tracheal, or windpipe, "lung." The supporting cartilaginous bands around the windpipe are incomplete, opening toward the top of the body. The tissue between the open ends of the bands is ballooned out and is structurally modified into a lunglike tube that runs along the windpipe and that functions as a lung. Some sea snakes can extract oxygen from water through the tissues lining the mouth, and both sea snakes, family Hydrophiidae, and file snakes, family Acrochordidae, can use their skin for respiration when submerged.

Circulation. For a description of the three-chambered heart and the circulatory system of snakes, see REPTILE.

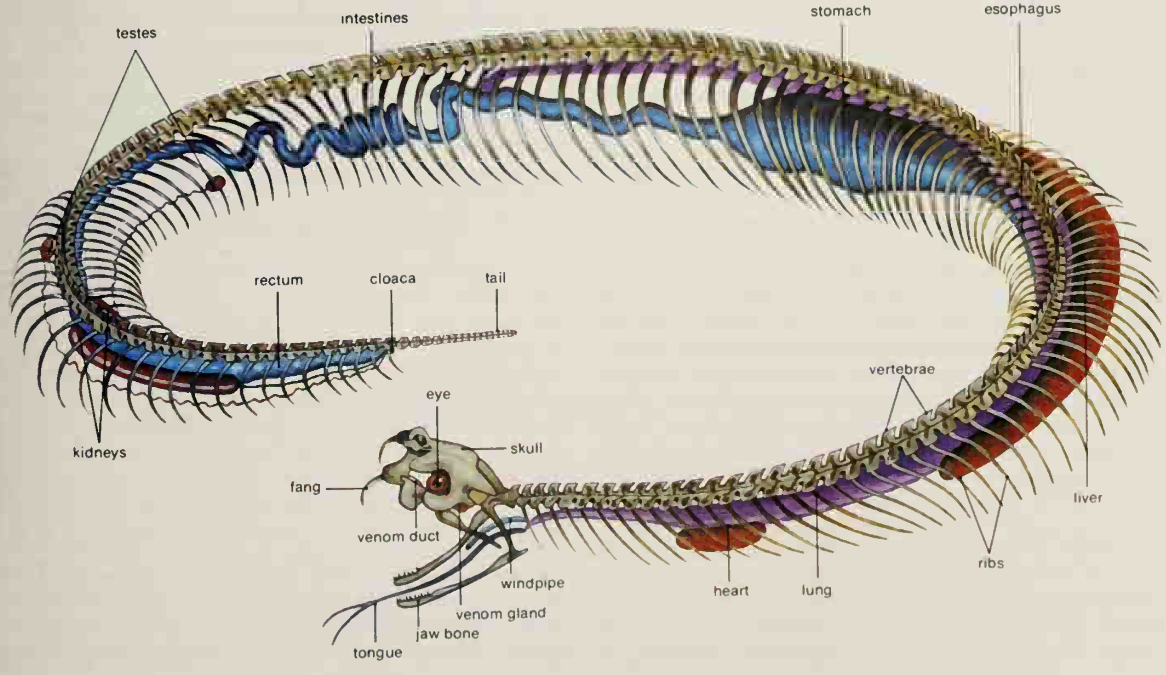
Molting. Because the outer layer of the skin does not increase in size or because it becomes worn, or because of reasons not yet understood, a snake must periodically shed its old skin and replace it with a new and larger one. In molting, the old, upper layer of the epidermis becomes loosened and separated from a newer layer developing beneath it. The molting process, or ecdysis, is accomplished by the snake loosening the skin around the lips, pushing this back, and crawling out of the old skin, turning it inside out.

Feeding

All snakes are carnivorous. Many of the smaller burrowing forms feed on earthworms or insects. Some snakes have specialized food habits, preying exclusively on snails or eggs. Others feed on fish, amphibians, reptiles (including other snakes), birds, or small mammals, or a combination of these. Snakes find food by sight or by smell (using the Jacobson's organ as an accessory) and by heat-sensitive pits, when present. A few species are active at any time of the day, but most species restrict their activities to either daylight or nighttime. The more slender and agile snakes actively stalk their prey; the heavier-bodied ones remain coiled in ambush.

Constriction. Some snakes simply suffocate their captured prey by squeezing it with their jaws, but a snake's long, muscular body is ideally suited for applying pressure

Snakes lack limbs, a shoulder girdle, and a breastbone. The skeleton consists of a skull, with loosely attached jaw bones, and numerous vertebrae—more than 400 in some species—and ribs. The long, thin internal organs are adapted to the snake's slender body. Most snakes have only one functional lung; the digestive system includes a thin esophagus and a flexible stomach with an extremely large capacity.



All snakes are carnivorous and swallow their prey whole (left). *To pull the meal into its throat, the snake usually "walks" the sides of its jaws forward over the animal: in alternating order, one side holds the prey while the other side moves forward. Food items may include fish, amphibians, birds, small mammals, or other snakes. Many snakes swallow their prey alive; others use venom or constriction to kill an animal before swallowing it. A constricting snake, such as the royal python* (right), *of western Africa, wraps its body around prey and contracts its muscles. The constrictor kills its victim by causing it to suffocate rather than by crushing it.*

on a prey animal. Constriction has been defined as the immobilization of prey by the exertion of pressure by two or more points of the snake's body. Constriction does not crush the prey animal but rather prevents it from breathing and suffocates it. Some snakes use one or two body loops to press their prey against the ground, or against the inside of a burrow if below ground. Others wind or wrap around their prey.

Envenomation. Snakes have powerful digestive enzymes (specialized proteins) to break down the hair, feathers, bones, and other parts of their prey. As part of the digestive system, the salivary glands of the mouth also produce powerful enzymes. If saliva containing these enzymes enters the wounds of a prey animal, it not only begins the digestive process but also may cause such serious tissue damage that the prey dies. Such toxic elements have been found in the saliva of many nonpoisonous snakes, and they are generally introduced into the prey's wounds by repeated bitings by the snake; obviously, a more toxic saliva (venom) and a more effective means of introducing it into a wound would be of great advantage. In the most primitive venomous snakes, the rearmost teeth, usually the last two or three on each side of the upper jaw, are enlarged into fangs. Each fang has an open groove on the front or side. Venom from the modified salivary glands above is discharged at the base of the teeth and conducted by the grooves into the wound. Such snakes are called opisthoglyphs ("rearward" and "carved") or, more commonly, back-fanged snakes.

Two more-efficient systems involve placement of the fangs in the front of the mouth. In proteroglyph ("frontward" and "carved") snakes, such as cobras, the poison-conducting groove in each of the two fangs is closed over for most of its length, forming a more efficient venom canal. Proteroglyph venom is also usually quite potent. In solenoglyph ("tube" and "carved") snakes, the two poison-conducting fangs are formed into hollow, venom-conducting tubes, that can be folded back along the roof of the mouth, allowing solenoglyph snakes, such as rattlesnakes, to develop very large fangs. Most solenoglyphs also have potent venom.

The destructive substances in venom include neurotoxins and hemotoxins. Neurotoxins paralyze the nervous system and cause heart and respiratory failure; hemotoxins destroy blood vessels and blood cells and cause internal hemorrhaging. The different substances are not uniformly present in all snake venom but vary with the species and even with individual snakes within a species. Venom retains digestive powers; injected into a prey animal it may shorten the usual days-long digestive process of a snake by more than half.

Less than one-third of the 2,500 to 3,000 snake species are classified as poisonous, and fewer than 300 species may be fatal to humans. In the United States more than twice as many people are killed each year by bee, wasp, and scorpion stings as by snakebites. It should be noted, however, that the presence of toxic elements in the saliva of many so-called nonpoisonous snakes makes it difficult to make a sharp distinction between venomous and nonvenomous types.

Swallowing. Lacking limbs to force whole prey animals into the throat, snakes must generally "walk" their jaws forward over the prey animal rather than simply swallowing it.

Locomotion

There are four basic kinds of snake movement: lateral (horizontal) undulation, concertina movement, sidewinding, and rectilinear movement. Lateral undulation, also called serpentine movement, is the most common form and is used by all snakes. By alternately contracting and relaxing muscles down each side of the body, the snake forms itself into a number of rearward-moving horizontal waves. While doing so, the snake maneuvers its body so that the rear of each backward-moving wave pushes against something resistant.

In concertina movement, also called earthworm movement, the snake anchors the forepart of its body and then pulls up the rest of its body behind it in the form of horizontal curves; it then extends out the forepart of its body, anchors it, and repeats the process.

Sidewinding is employed on soft sand or other surfaces that offer no resistance or grip. In sidewinding, the snake loops its body into an S-shape, with only two sections of the body in contact with the ground. It then progressively shifts the two contact points farther back along the body, consequently pushing itself ahead. A new contact point is begun at the head when one contact point reaches the tail.

Rectilinear, or caterpillar, movement involves a sliding of the skin back and forth over the body musculature and is therefore possible only in those snakes, such as rattlesnakes and boas, which do not have the skin tightly attached to the underlying musculature. The ribs remain essentially motionless, and the scales provide only body-to-ground friction.

Speeds attainable by snakes have been greatly overestimated. One of the fastest North American snakes, the whip snake, *Masticophis*, has a top speed of only 6.4 km/h (4 mph). The black mamba, *Dendroaspis polylepis*, may be the world's fastest snake and has been clocked at 11.2 km/h (7 mph).

Reproduction and Longevity

Courtship among snakes usually involves the male aligning along the female in a series of spasmodic jerks and rapid tongue flicking. Eventually, if the female is receptive, the male inserts one of the paired copulatory organs (hemipenis) and mating ensues, lasting several hours to about a day. In snakes of the family Boidae, the male's spurs may play an important courtship role by stroking or vibrating against the female and thus helping to position her.

The vast majority of snakes lay eggs, but in some the eggs are retained in the female until hatched, and the young are born alive (ovoviviparity). Pythons have laid more than 100 eggs in a single clutch, and some live-bearing snakes are remarkably prolific. The number of eggs or young is dependent on the species and on the size of the female parent. No true parental care of young is known, but a few snakes brood their eggs until they hatch. Gestation and incubation periods vary according to the species and temperature. Young snakes escape from the egg by splitting the shell with a special structure, the egg tooth, which falls off shortly after hatching.

Snakes have relatively long life spans, and many have survived in captivity for more than 20 years.

Origins

The origin of snakes is obscure because their skeletons are fragile and make poor fossils. One of the earliest known snake fossils is the 1.8-m (6-ft) *Dinilysia* from the Late Cretaceous Period (about 70 million years ago) of Patagonia. Two schools of thought concerning snake evolution are that (1) snakes arose from a superfamily of lizards, the Varanoidea, or Platynota, which includes several living families that have snakelike characteristics, or (2) they evolved from limbless, burrowing lizards in which the eyes had degenerated. These views need not be mutually exclusive, because it is possible that, although no living members of the Varanoidea now lack limbs or have degenerate eyes, extinct species may have possessed these distinctive characteristics of burrowers.

Classification

Snakes are classified in the class Reptilia, subclass Lepidosauria, order Squamata, suborder Serpentes. The suborder Serpentes is divided into three infraorders. Members of the infraorder Scolecophidia are the most primitive snakes, having cylindrical bodies, short tails, traces of the pelvic girdle, and a multilobed liver. The infraorder is divided into two, or sometimes three, families of small burrowing snakes (blind snakes, Typhlopidae; slender blind snakes, Leptotyphlopidae; and, sometimes, anomalepid blind snakes, Anomalepidae) that are highly specialized for a subterranean existence.

The infraorder Henophidia includes families possessing both primitive and advanced characteristics. The family Boidae contains some of the world's largest snakes (pythons, boas, anacondas). Most members of this family retain vestiges of the pelvic girdle and also of the hind limbs, which are present in the form of spurs. Members of the family Aniliidae are stout-bodied, short-tailed, cylindrical snakes. They are generally less than 1 m (3.3 ft) in length and are found in South America, Southeast Asia, and the Greater Sunda Islands (East Indies). The family Uropeltidae is made up of small, secretive burrowers found in damp places in mountainous regions of India and Sri Lanka (Ceylon). These snakes have an enlarged scale at the end of the tail, the function of which has never been convincingly explained. The family Xenopeltidae contains only one small species in Southeast Asia. Its common name is the sunbeam snake, and it is appropriately named, for its scales are highly iridescent. It is secretive and nocturnal. Some of the strangest snakes belong to the family Acrochordidae, variously called file snakes, wart snakes, or the elephant-trunk snakes. These aquatic snakes are covered with small, granular scales. They range over parts of India, Indochina, and the Indo-Australian archipelago.

Most snake species are in the advanced infraorder Caenophidia and are characterized by a complete absence of the pelvic girdle. The Colubridae are the largest family of snakes. Most are small and harmless, but a few species possess enlarged teeth (venom fangs) on the posterior portion of their upper jaws (opisthoglyphous condition). The Elapidae are a family containing extremely venomous snakes: coral snakes, cobras, kraits, mambas, and sea snakes (sea snakes are often placed in a family of their own). These have a relatively short, permanently erect fang on the front part of the upper jaw (proteroglyphous condition). The family Viperidae includes the true vipers, which lack heat-detecting pit organs (subfamily Viperinae), and the pit vipers, which possess those organs (subfamily Crotalinae). In some classifications, the pit vipers are considered a separate family. Possibly included in the Viperidae are the mole vipers, *Atractaspis*, but the relationships of this group have been seriously questioned, and they may represent a highly modified colubrid line. Viperid snakes have long, recurved, erectile fangs (solenoglyphous condition).

snake dance The snake dance is an annual religious ceremony of the HOPI Indians of northeastern Arizona, usually held in August. The snake ceremony combines the worship of the totemic ancestors of the Snake Clan with a ritual plea for rain. After 8 days of secret rites in the underground ceremonial chambers called kivas, the climax of the ceremony occurs in a public performance on the afternoon of the 9th day, when the dancers fearlessly handle live snakes and carry them in their mouths. At the end of the rite the snakes are released, to carry the Hopi pleas for rain to the gods in all directions.

snake eel Snake eels, family Ophichthidae, are nocturnal, burrowing, deep-sea fishes, primarily tropical and subtropical. They lack pelvic fins, scales, and a caudal fin, and the dorsal fin is reduced in size and sometimes absent. The tail is thick-skinned and sharply pointed for burrowing. Snake eels have reduced eyes, sharply pointed snouts, fanglike teeth, and the posterior nostril on or inside the upper lip. Generally bright in color, adults are spotted or banded, or both, and range from 30 to 135 cm (12 to 53 in) in length.

snake fly The snake fly (suborder Raphidioidea, order Neuroptera) is a predaceous, lacewinglike insect 10–20 mm (0.4–0.8 in) in length. It has a long necklike prothorax and can raise its head above the rest of the body, thus resembling a snake ready to strike. The larvae usually occur under bark, where they feed on various small insects. The snake fly occurs in the United States only in the western states, particularly in California.

snake plant About 50 species of the genus *Sansevieria*, in the family Agavaceae, are known as snake plants. The best-known species is *S. trifasciata*, an evergreen plant from tropical Africa and the East Indies that is commonly grown indoors for its foliage. Long, sword-shaped leaves that are variegated and leathery arise from a short, thick rhizome. Leaves of all species of *Sansevieria* have strong fibers, and some species are used for making rope, fiber mats, and bow strings for hunting.

Snake River The Snake River, in the northwestern United States, is the largest tributary of the COLUMBIA RIVER and the ninth largest river system in North America. Rising in Wyoming in the southeastern section of Yellowstone National Park, it flows through Wyoming, Idaho, Oregon, and Washington for about 1,670 km (1,040 mi). With its tributaries—the Wind, Bruneau, Salmon, Powder, Clearwater, and Palouse rivers—the Snake drains an area of 282,000 km^2 (109,000 mi^2). After leaving Wyoming at the Palisades Reservoir, it twists across the plains of southern Idaho, passing Idaho Falls and the Boise agricultural regions. At the Idaho-Oregon boundary it flows north through the 200-km-long (125-mi), 2,408-m-deep (7,900-ft) Hell's Canyon, the deepest gorge in North America, to Lewiston, Idaho, at the Washington border. The Snake then flows generally west and southwest to join the Columbia at Burbank, Wash. Several areas of rapids and waterfalls occur along the river, which has been dammed in many places for power and irrigation. Wildlife is abundant along the river, which was an important early route to the Pacific Northwest.

snakeroot Snakeroot, or serpentaria, is the common name for any of several plants, including white snakeroot, *Eupatorium urticoefolium*. A tea made from the root of these plants was formerly used as a tonic and even earlier was used as a folk medicine to treat snakebite. No known constituents of the root, however, have any beneficial effect against snake venom.

SNAP SNAP, an acronym for Systems for Nuclear Auxiliary Power, is a program begun by the Atomic Energy Commission (now incorporated into the Department of Energy) to develop small, independent power sources for scientific equipment operating in remote areas and for space probes operating too far from the Sun to rely on solar electric cells. Electrical power output has ranged from a few watts to more than 30 kW.

A few SNAP units have been true nuclear-fission reactors, but most SNAP units have been thermocouple devices using the heat of radioisotope decay.

SNAP units have powered unmanned Earth satellites (Nimbus, Snapshot, Transit), *Pioneers 10* and *11*, the *Viking 1* and *2* landers, and *Voyagers 1* and *2*. Others have been used to power weather stations in the Arctic and Antarctic, navigation buoys and beacons, offshore oil platforms, and remote ocean-science stations.

snapdragon Snapdragons are a genus, *Antirrhinum*, of flowering plants in the figwort family, Scrophulariace-

Common snapdragons are grown in flower beds and are popular in cut floral arrangements. Children like to pinch the base of the flower, causing it to snap open and shut.

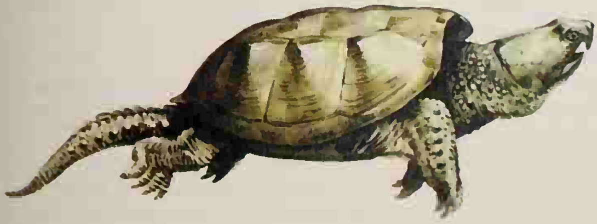
ae. The common snapdragon, *A. majus*, is the most popular species used in gardening. It is an annual or perennial that grows 90 cm (3 ft) tall and has white to purplish red flowers up to 3.75 cm (1.5 in) long. Hybrids have many intermediate shades of color.

snapper Snappers are approximately 230 species of marine food fishes constituting the family Lutjanidae. They range up to about 1 m (3 ft) in length and are generally characterized by large jaws, sharp teeth, and a downward-sloping snout. Snappers usually occur in small groups, but the schools of some species of *Caesio* may contain millions of individuals. Most snappers are found inshore, but some live in midocean or at considerable depths. Many are primarily nocturnal, and some are color-blind. A number of the fish-eating species may cause tropical fish poisoning, or ciguatera. The ciguatera toxins, which affect the nervous system and are sometimes fatal, may be due to the snappers eating fish that had fed on toxin-producing blue-green algae or possibly diatoms.

The yellowtail snapper swims in schools among reefs of the Atlantic tropics. It is caught commercially as a food fish.

snapping turtle The snapping turtles, family Chelydridae, can be recognized by their small lower shells (plastrons), long tails, large heads with powerful jaws, and ugly dispositions. They will feed on almost anything. Conversely, the common snapping turtle is the native species most frequently eaten by people in North America. The common snapping turtle is usually regarded as a single, widespread species, *Chelydra serpentina*, ranging from southern Canada to Ecuador; in the United States the species ranges from the Atlantic coast to the Rocky Mountains. (Some authorities regard the Southern Florida population as a separate species, *C. osceola*.) It reaches 47 cm (18.5 in) in shell length and in the wild may weigh up to 16 kg (35 lb). The alligator snapping turtle, *Macroclemys temmincki*, is one of the largest freshwater turtles. It commonly varies between 38 and 66 cm (15 and 26 in) in shell length and from 16 to 68 kg (35 to 150 lb) in weight, and it is found from the Gulf States northward to Illinois and Iowa. It often sits under the water with mouth agape and wriggles a projection on its pink tongue that resembles a worm and serves as a lure.

The common snapping turtle has powerful jaws and a long, saw-toothed tail; its massive shell varies from tan to black.



snare drum The snare drum, also called side drum, is the smallest drum in the tradional symphony orchestra. It is cylindrical in shape with two heads. The upper, or batter, head is struck with a pair of sticks or, sometimes in popular music, metal brushes. The lower, snare, head has beneath it a series of strings wound with wire, called snares. Strokes on the batter head are transmitted to the snare head by air set in motion inside the drum. This activates the snares, which vibrate against the snare head, doubling its vibrations.

SNCC The Student Nonviolent Coordinating Committee (SNCC) was founded in the United States in 1960, with the help of Dr. Martin Luther KING, Jr., to work for CIVIL RIGHTS in the deep South. The movement grew out of a sit-in of four students at a lunch counter in Greensboro, N.C. In addition to coordinating sit-ins in the South, SNCC organized voter-registration campaigns. In 1966, however, the organization embarked on a more radical path. The new chairperson, Stokely Carmichael, and his successor (1967), H. Rap Brown, repudiated integration in favor of "black power." By the beginning of the 1970s the organization had lost political effectiveness.

Snead, Sam [sneed] Samuel Jackson Snead, b. Hot Springs, Va., May 27, 1912, began his golfing career as a caddie in his hometown. He turned professional in 1934 and joined the Professional Golfers' Association (PGA) tour in 1937, scoring his first victory in the Oakland Open. His smooth swing and long drives soon earned him the nickname "Slammin' Sammy." In 1949 and 1950, Snead was the leading money winner, and in 1938, 1949–50, and 1955 he won the Vardon Trophy for the lowest-strokes-per-round average. With victories in the 1949 PGA and Masters tournaments, he was selected Player of the Year. During his career Snead achieved 81 victories, more PGA wins than any other professional golfer in history. He won the PGA 3 times (1942, 1949, 1951), the Masters 3 times (1949, 1952, 1954), and the British Open (1946). In addition, he has won the PGA Seniors' title 6 times. Snead came close to winning the U.S. Open in 1939, but lost because he took eight strokes on the final hole. He was inducted into the PGA Hall of Fame in 1953.

sneezeweed Sneezeweed is the common name for plants in two genera of the family Compositae that are suspected of causing hay fever. *Achillea ptarmica* is naturalized in eastern North America from Europe and Asia; species of *Helenium* are native to North and South America. Both genera contain glucosides that are poisonous to cattle.

Snefru, King of Egypt [snef'-roo] Snefru, who was probably the first king of the Egyptian 4th dynasty (*c*.2613–*c*.2494 BC), built the earliest surviving examples of true PYRAMIDS. His reign, for part of which extensive records exist, appears to have been a time of prosperity. Snefru raided Nubia and Libya, and also conquered Sinai. He was responsible for the construction of two pyramids at Dahshur, one of them showing faults that indicate this attempt may have been the first at building such a structure.

Snell, Peter A runner from New Zealand, Peter George Snell, b. Dec. 17, 1938, was the world's best at the middle distances during the period 1962–64. He won a gold medal for the 800-m run at the 1960 Olympics, and in 1964 he took the 800-m and 1,500-m gold medals. Between Olympiads, Snell set world records at 800 m, 880 yd, 1,000 m, and the mile, finally lowering the latter to 3 min 54.1 sec in 1964.

snipe Snipes are small game birds belonging to the SANDPIPER family, Scolopacidae. They measure 28 cm (11 in) in length and have long, straight bills. Their mottled brown-and-white plumage blends well with their wetlands cover, and they have a swift, zigzag flight. The common snipe, *Capella gallinago*, of both the Old and the New World, is the only species regularly found in North America. Some similarly long-billed birds also are colloquially called snipe, including the American woodcock and the dowitchers.

Snodgrass, W. D. [snahd'-gras] The American poet and translator William DeWitt Snodgrass, b. Wilkinsburg, Pa., Jan. 5, 1926, was awarded the Pulitzer Prize for his first book of poems, *Heart's Needle* (1959). That and his second volume, *After Experience* (1968), were characterized by a confessional tone and the use of traditional forms. Snodgrass's more recent verse—such as *If Birds Build with Your Hair* (1979)—has a freer structure.

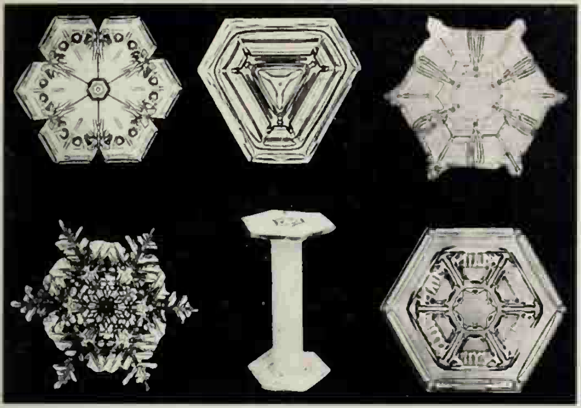
Snorri Sturluson [snor'-ee stur'-loo-sohn] Snorri Sturluson, b. *c*.1179, d. Sept. 23, 1241, was an Icelandic historian and poet whose works typify the golden age of ICELANDIC LITERATURE. He is the author of two major works: *Heimskringla* (*c*.1220–35; trans. 1964), a history of the kings of Norway; and the *Edda* (usually called the *Younger* or *Prose Edda*, *c*.1222; trans. 1954), a handbook for poets containing a treasury of mythological lore. He is also the probable author of *Egil's Saga* (*c*.1226; trans. 1960), one of the major sagas. Snorri was active in the violent political struggles of his time and served three terms as law speaker of the Icelandic commonwealth. He was killed at the instigation of King Haakon the Old of Norway.

Snow, C. P., Baron Snow The life of Charles Percy Snow, Lord Snow, English novelist, civil servant, and physicist, b. Oct. 15, 1905, d. July 1, 1980, illustrated that his proclaimed division of Western society into "two polar cultures"—sciences and humanities—need not be absolute. Snow earned a doctorate (1930) in physics at Cambridge, recruited scientific talent for the Ministry of Labour during World War II, and later served (1964–66) as a member of parliament and of the cabinet. The semiautobiographical *Strangers and Brothers* (1940) was the first in the series of novels that was to make Snow's name as a writer and that would provide a collective title for all 11 works. It introduces Lewis Eliot, whose narrative eventually portrays English society from the end of World War I to the 1960s. Other novels in the series include *The Masters* (1951), *The New Men* (1954), and *Corridors of Power* (1964). Snow was married to the novelist Pamela Hansford Johnson, with whom he wrote several plays. He was made a life peer in 1964.

Although Lord Snow had a distinguished career as a scientist and civil servant, he was best known as C. P. Snow, author of Strangers and Brothers *(1940–70), an 11-volume work of fiction.*

snow and snowflake Snow is composed of small crystals of frozen water; the crystals form directly by condensation of atmospheric water vapor around solid nuclei at temperatures below 0° C (32° F). As individual crystals of ice (snow crystals) fall through the atmosphere, they cluster together and form snowflakes. The term *snow* is also applied to deposits on the ground that may occasionally cover as much as 23 percent of the Earth's land surface.

Because the quantity and frequency of snowfall vary with the availability of moisture and the prevalence of below-freezing air temperatures, annual rates of snowfall can range from several meters of water-equivalent in plac-



The vast majority of snow crystals occur in a hexagonal, or six-sided, form as a result of the arrangement of oxygen atoms within the crystals. The exact form is directly related to the temperature, and a seemingly limitless variety of shapes can be found.

es such as the high mountain snow fields of the Pacific Northwest of North America to less than 2 cm (0.8 in) of water-equivalent in the interior of Antarctica.

Formation. Snow crystals forming at temperatures above –40° C (–40° F) generally need foreign particles on which to nucleate. This kind of nucleation is termed *heterogeneous.* The most common types of nuclei are silicate minerals of terrestrial origin and sea salt. Locally, particles from industrial sources and automobile exhaust may also be important. Nuclei range in size from 10^{-5} to 10^{-2} mm. At temperatures below –40° C water can solidify spontaneously, without the need for nuclei, by a process called homogeneous nucleation.

Ice-crystal formation in the atmosphere can be stimulated artificially by injecting silver-iodide particles into a supercooled cloud. Attempts at large-scale seeding of clouds to induce precipitation of snow and rain have been only partially successful.

The shapes of snow crystals depend largely on the temperature of formation and to a lesser extent on the atmospheric humidity. The size of a crystal appears to depend mainly on the moisture content of the air. Because absolute moisture content of the atmosphere increases with increasing temperatures, crystals formed at higher temperatures tend to grow larger than those at lower temperatures.

Changes in Snow Cover. Because freshly deposited snow is frequently light-textured and fluffy, winds may redistribute it into characteristic surface features such as snow dunes and sastrugi. Further changes in the snow cover, such as rounding of snow grains and significant changes in density, cohesiveness (degree of intergranular bonding), and hardness, occur mainly in response to temperature fluctuations. Snow that has survived at least one year is called firn. In the snow fields of mid-latitude glaciers, refreezing of summer meltwater, together with densification resulting from the weight of the overlying snow, causes the firn to transform rapidly into glacier ice. On a large polar glacier such as Antarctica, however, where surface air temperatures rarely reach 0° C, the transformation of firn to glacier ice may take hundreds or even thousands of years to accomplish.

snowberry Snowberry, or waxberry, is the common name for 16 species of shrubs in the genus *Symphoricarpos,* family Caprifoliaceae, in particular *S. albus.* This plant, a small, deciduous, berried shrub of North America, produces thin stems that bend under the weight of puffy white- or pink-tinted berries. Snowberries grow to 90 cm (3 ft) and make useful decorations in winter.

The name snowberry is also given to about 20 species of tropical American shrubs and vines constituting the genus *Chiococca* in the madder family, Rubiaceae.

Snowdon, Antony Armstrong-Jones, 1st Earl of [snoh'-duhn] Antony Charles Robert Armstrong-Jones, 1st earl of Snowdon, b. Mar. 7, 1930, an English photographer and writer, married Princess Margaret Rose, sister of Great Britain's Queen Elizabeth II, in 1960. Armstrong-Jones, educated at Eton and Cambridge, designed (1965) Snowdon Aviary at the London Zoo and helped to film many television productions, including the award-winning "Don't Count the Candles" (1968). His published works include *Sittings: 1979–83* (1983). He and the princess were divorced in 1978.

snowmobile *Snowmobile* is the generic word for a large group of powered vehicles used for transportation and recreation over snow and ice. Until about 1950 there were few in regular use, although patents for powered sleds date back to the late 1800s. Modern snowmobile design can be traced to the Canadian Joseph Armand-Bombardier. His troop-carrying snow vehicles, built during the 1930s, have many of the same features found in

Snowmobiles race near Malone, N.Y., during the Eastern Snowmobile Championships. The speed record for these half-tracked, engine-driven vehicles was established in 1982 by the American Tom Earhart, who achieved a speed of 239.1 km/h (148.6 mph).

today's snowmobiles: a half-track driven by a gasoline engine in the rear of the vehicle to provide the motive power, and steerable, ski-type runners supporting the front end.

Snowmobiling has become a popular winter sport in North America, in part due to the influence of snowmobiling clubs. Larger vehicles are available for special purposes. On the Antarctic continent the overall length of the snowmobile is increased, and the tracks and skis are arranged to aid in avoiding crevasses or bridging them successfully. Four-track vehicles are common in the Antarctic. In most cases the snowmobile has replaced the DOGSLED.

The number of recreational snowmobiles has given rise to concerns about their potentially damaging effect on wildlife habitats in areas that were previously unreachable by any type of motorized vehicle.

snowshoe Snowshoes enable a person to walk rapidly across even soft, deep snow without sinking because they distribute the weight of the wearer over a large surface. The frame of the tennis-racket-like snowshoe is about 1 m (3 ft) long and 46 cm (1.5 ft) wide; it is made of bent wood strengthened by wooden crossbars and laced with rawhide. First worn by North American Indians and Eskimos, snowshoes today are used by hunters, trappers, loggers, farmers, and sportspeople.

Snowy Mountains The north-south trending Snowy Mountains are located in the Australian Alps in New South Wales, Australia. Covered by snow for six months of the year, the range has an average elevation of 760 m (2,500 ft). Lying within the Snowy Mountains is Mount KOSCIUSKO, the highest peak of Australia. The range, first explored in 1840 by Paul Strzelecki, is a site of an irrigation and hydroelectric power project. The Snowy Mountains Hydroelectric Authority diverts water from the Snowy River through the mountains to irrigate the arid interior of the continent.

Snyder, Gary Best known as a poet, Gary Sherman Snyder, b. San Francisco, May 8, 1930, was brought up in poverty on his parents' farm north of Seattle. He attended Reed College, where he developed sympathies for anarchist ideas and radical politics. Snyder became a sailor, worked for the Forest Service, and did graduate work in linguistics at Indiana University. While studying Oriental languages at Berkeley (1953–56), he met Allen Ginsberg, Jack Kerouac, and other members of the BEAT GENERATION. Kerouac later memorialized Snyder as Jaffy Ryder in *The Dharma Bums.*

Snyder spent most of the period between 1956 and 1964 as a lay acolyte learning the strenuous discipline of Zen Buddhism in Daitoku-ji, a monastery in Kyoto, Japan. His poems celebrate communal life and advocate an existence controlled by the rhythms of nature. Snyder won a Pulitzer Prize for poetry in 1975.

Soane, Sir John [sohn] The career of the English architect Sir John Soane, b. Sept. 10, 1753, d. Jan. 20, 1837, spans the period of the classic revival; he was a leader as well as an innovator within this movement, bringing a new taste for the "picturesque" into fashion with his novel interpretations of Greek and Roman architecture.

In 1788, Soane was appointed architect to the Bank of England, which he remodeled and greatly enlarged over the next 40 years. His work on the bank survives only on the exterior.

Soane's interest in the picturesque dates from around 1800. His Dulwich Art Gallery (1811–14) near London is a surviving example. The profile of the building is not tied together into a cumulative entity, as in buildings of the baroque; instead, each element is separated and divided to make a plain, pared-down structure with each part clearly and simply articulated. In his own large row house (1812–13) at Lincoln's Inn Fields, London, Soane used many ingenious if idiosyncratic architectural devices to break up the monotony of cubic rooms. It is now the Sir John Soane Museum and houses Soane's large art collection.

Soane's last major work was the Stables of the Royal Hospital, Chelsea (1814–17), which are plain and practical in design. He was appointed professor of architecture at the Royal Academy in 1806 and knighted in 1831.

Soap Box Derby The Soap Box Derby is an annual racing tournament for coasting cars that are designed, built, and driven by 9- to 16-year-olds. The cars may use only gravity to propel them down an incline. Thousands of American youngsters compete for fewer than 200 places in the national finals held each August.

Rules restrict the cost, size, and weight of the cars. Although cars were once made out of wooden soap boxes, fiberglass is now the most common construction material.

The first Derby was held in Dayton, Ohio, in 1934. The following year it moved to Akron, Ohio. In 1936, Derby Downs was built in Akron, and the race has been held there ever since, except for a 4-year interruption during World War II.

soap and detergent Soap is a natural cleansing agent produced by the reaction of an alkali, such as sodium hydroxide, with animal fat or vegetable oil. Soap classifications include toilet soap, which is manufactured as a cleansing agent for the body, and soaps for household use, such as bars, flakes, and granules.

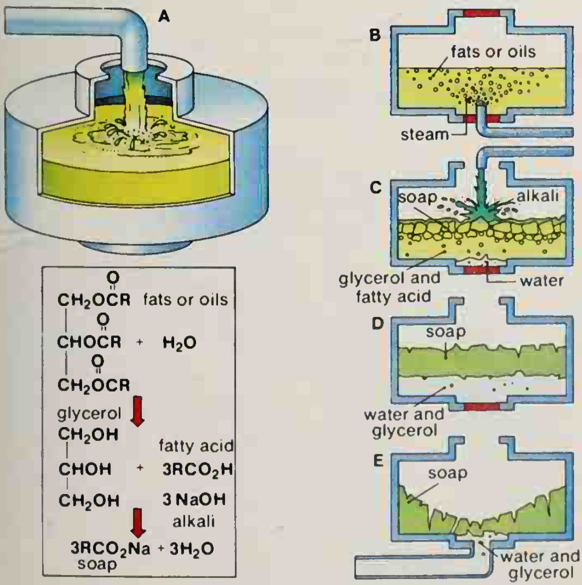
A detergent is a cleansing preparation synthesized from a number of readily available raw materials, usually petrochemicals. All detergents use a surface-active agent (surfactant) to lower the surface tension of water and dislodge dirt from surfaces, emulsify it, and suspend it in water. Detergents often contain, in addition, a builder, used for controlling minerals in hard water, providing alkalinity and buffering so that alkalinity is maintained at an efficient level, suspending soil particles and controlling the redeposition of soil, emulsifying oily soil, and enhancing the surfactant's wetting action. Other ingredients may include brighteners, bleaches, suds-control agents, perfumes, and colorants.

The Cleansing Process. A number of physical and chemical processes occur simultaneously during washing. The basic explanation of how soaps and detergents work is that their surfactant molecules have polar, or hydrophilic, ends, which attract water molecules; and nonpolar, or hydrophobic, ends, which repel water. By lowering its surface tension, the molecules improve water's ability to penetrate and loosen soil. The opposite attractions of the molecule loosen the dirt, often aided by hand or machine agitation. The molecules then surround and suspend dirt particles in the water until they are rinsed away.

Soap, however, presents problems in hard water, because the water-seeking portion of the molecule unites with some minerals in water to form an insoluble curd, leaving visible deposits on clothing, bathtubs, and washing machines. Most detergent surfactants do not form curds, and builders in detergents control those properties in the wash water which reduce the surfactant's effectiveness.

History of Soaps and Detergents. Soap has been used for millennia, whereas detergents are relatively new. Mesopotamian clay tablets dating from the 3d millennium BC contain a soap recipe calling for a mixture of potash and oil. The first authentic reference to soap as a cleansing agent as well as a medicinal product appears in the writings of Galen, the 2d-century AD Greek physician. The ancient Romans spread their knowledge of soapmaking, and in the Middle Ages important centers of soapmaking developed in Spain, France, and England. Discoveries by Nicolas Leblanc in the 18th century and Michel Eugène Chevreul in the 19th century made it possible to manufacture soap according to a formula, with exact and predictable results.

Modern processes for continuous soap manufacture (A) *begin with rapid hydrolysis, or chemical breakdown, of fats and oils by water at high temperature and pressure* (B). *The resulting hydrolysis products—fatty acids and glycerol—are treated with alkali* (C), *which saponifies, or reacts with the fatty acids to produce soap* (D). *The soap then is separated from the mixture* (E), *washed, dried, and formed into bars.*



The formation of curd when soap is used in hard water provided the impetus for developing detergents. The first light-duty detergents, introduced in the United States in the early 1930s, had limited cleaning ability. The first synthetic detergent, which provided the benefits of the early detergents as well as all-around cleaning power, was introduced after World War II. A key factor in producing these products was the development of complex phosphates, primarily sodium tripolyphosphate.

Some early detergent surfactants were slow to biodegrade; that is, bacteria could not break them down rapidly, and they caused foaming in sewage-treatment plants and streams. New biodegradable materials were introduced in 1965 and are now used exclusively throughout the United States.

Phosphate builders, which contain the element phosphorus, have also been implicated in environmental pollution. Phosphorus stimulates the growth of algae, helping accelerate EUTROPHICATION in lakes and bays. To add cleaning power to new, phosphate-free detergents, manufacturers use extra surfactants and digestive ENZYMES.

soap opera The term *soap opera* refers to serialized domestic dramas that were so named because, during the 1930s, when they were first broadcast on radio, their principal sponsors were soap companies. The plots, which often take years to unravel, usually focus on the romantic difficulties of stereotyped middle-class characters. During the 1960s, soap operas virtually disappeared from radio, but the format has proved so successful on television that much of daytime programming is now given over to soap operas, and in the 1980s the genre was up-classed to prime time in such once-a-week serials as "Dallas." The soap-opera public, once restricted to housewives, has broadened to include every segment of the national audience. That public also reads about the soap stories and stars in a group of new magazines and books devoted solely to the soaps.

soapberry Soapberry is the common name for about 13 species of trees of the genus *Sapindus*, in the soapberry family, Sapindaceae. They are native to both the New and the Old World. The fruit contains a soapy substance called saponin that is used as a cleaning agent in the tropics. The leaves alternate and have 4 to 12 leaflets. The white flowers are small and occur in terminal racemes or panicles. There are 4 to 5 petals. The brown fruit has a soft pulp with the saponin. The Western soapberry, *S. drummondi*, a deciduous tree, and the false dogwood, *S. saponaria*, an evergreen, are the only soapberries native to the New World. The Chinese soapberry, *S. mukorossi*, an evergreen, is grown in Florida for its seeds, which are used for beads. A few soapberries are grown as ornamentals.

soapstone see TALC

Soares, Mário [swah'-ruhsh] Cofounder of Portugal's Socialist party, Mário Soares, b. Dec. 7, 1924, is the president of Portugal; he was prime minister from 1976 to 1978 and again from 1983 to 1985. A lawyer, Soares organized a movement against the dictatorial regime of António de Oliveira Salazar and was arrested and exiled in 1968 and again in 1970. He returned shortly after the 1974 revolution that ousted Salazar's successor Marcello Caetano and became foreign minister (1974–75) for the new military junta. In 1976 new elections resulted in a strong Socialist minority and Soares was selected to be premier. In 1978 he formed a short-lived coalition government. In 1983, after Socialist gains at the polls, he formed a second coalition, which governed until 1985. He was elected to the presidency in 1986.

Sobieski, John see JOHN III, KING OF POLAND

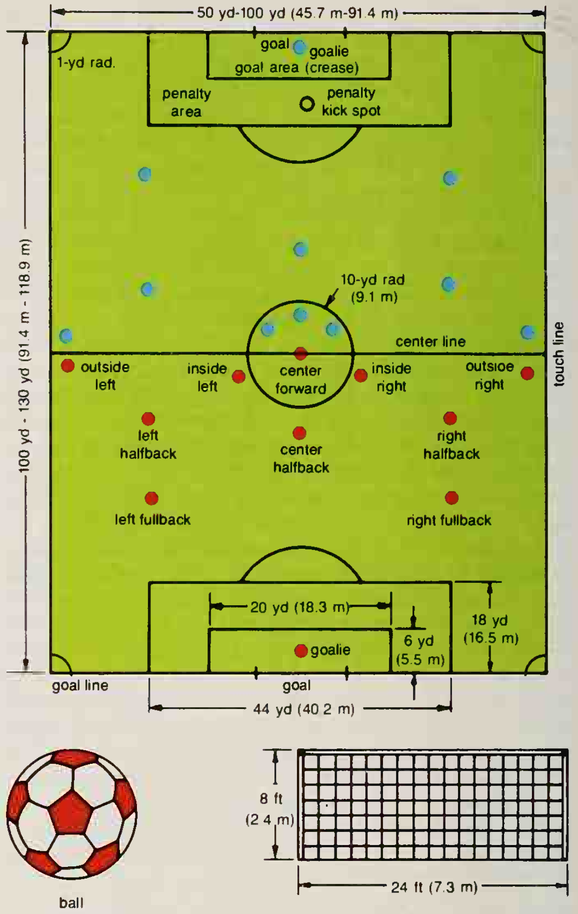
soccer Soccer is probably the most popular sport in the world. Two teams of 11 players attempt to guide an inflated ball into goal cages at opposite ends of a playing field. Soccer is unique because of its restriction on the use of the hands; only the goalkeeper may handle the ball, and then only within a limited area. The other 10 players must advance the ball using primarily their feet, although a proficient soccer player can use almost every part of the body—including the head—to control the ball.

The continuous action and fast pace of soccer have made it a major spectator sport throughout the world, and for the same reasons it has attracted millions of players. The name of the game presents some confusion. In countries other than the United States soccer is called football. The word *soccer* is a shortening and altering of *association football.*

The international governing body of soccer is the Fédération Internationale de Football Associations (FIFA), with headquarters in Zurich, Switzerland. Every 4 years national teams—made up of the top players from each country (who may play professionally for teams in other countries)—vie for the World Cup, soccer's most coveted prize. The 1990 World Cup finals had a television audience that exceeded a billion. The 1994 Cup will be hosted by the United States.

Rules of the Game

The rules of soccer are relatively simple, and little equipment is required. Players wear shirts, shorts, cleated shoes, and sometimes shin guards tucked inside their socks. The soccer ball, made of leather or rubber, has a circumference of 27–28 in (68.6–71.1 cm) and weighs 14–16 oz (397–454 g) when inflated to 12–13 psi (0.84–0.91 kg/cm^2). The length of the field may be 100–130 yd (91.4–118.9 m), and the width, 50–100 yd (45.7–91.4 m); the field must always be longer than it is wide. The dimensions and divisions of the field and the names of the players' positions are indicated in the diagram.



The diagram indicates the dimensions of a soccer field, which vary slightly according to the level and location of play. Also indicated are the dimensions of the goal and positions of the 11 players on a team in one of the many possible defensive alignments.

A soccer game begins when one team kicks off, the kicking team usually retaining possession because the ball need be moved only the length of its circumference with the kickoff. Play is continuous, stopping only when a goal is scored, the ball is out of bounds, or a foul is called. Each goal scored is worth one point, and the team with the most goals at the end of play wins. The game lasts for a specified period of time, which varies with the level and type of competition and sometimes the local rules. In most competition (including professional and U.S. intercollegiate), a soccer game is 90 minutes long, played in halves. Most U.S. interscholastic games comprise 15-minute quarters. Almost all levels of competition have provisions for some kind of overtime play to produce a winner if regulation time ends with the teams tied.

In international play substitution is generally limited to one or two players per game; players removed from a game for any reason (injury, ejection, substitution) cannot return. In U.S. collegiate and scholastic soccer, however, any player may leave and subsequently reenter the game at any time.

The game is controlled by a referee on the field who is assisted by two linesmen, one on each sideline. Intentional contact with the ball from the shoulders to the hands is forbidden, and the following constitute offenses against the opponent: intentional kicking, charging from behind or in a dangerous manner, striking, holding, pushing, tripping. For these the referee will stop play and award a direct free kick, from the point of the infraction, against the offending team. It is possible to score a goal directly with such a kick. If one of the offenses is committed by a player inside the team's own penalty area, then the other team gets a penalty kick; the ball is placed on the penalty spot, 12 yd (11 m) from the goal, and only the goalkeeper may defend.

Other, lesser offenses include obstruction and dangerous play, for which an indirect free kick is awarded; in this case one pass must be made before a goal can be scored. An indirect free kick is also awarded for offside violations. A player is offside if the following conditions exist: the player is in the opponent's defensive half of the field, the player's team—but not that player—has possession of the ball, there are less than two defenders between that player and the goal, and that player is in a position to affect the play.

Pelé, the world's most famous soccer player, led Brazil to three World Cup titles (1958, 1962, 1970). His brief stint (1975–77) with the New York Cosmos of the NASL did much to popularize soccer in the United States.

The linesmen have two main functions: (1) to spot offside infractions; and (2) whenever the ball goes out of play, to indicate which team has possession and where. When a ball goes beyond the sidelines, it is returned to play with an overhead, two-handed throw, with the player's feet touching the ground. When the ball goes over the goal line but not into the goal, it is either a corner kick for the attacking team (in which case the ball is kicked toward the goal) or a free kick downfield for the defending team.

History

Soccerlike games undoubtedly predate recorded history. Soccer historians find its ancestry in the similar but unstructured games of medieval English village life. When the London Football Association issued (1863) its first set of rules, order was brought to the sport. All major innovations in soccer were English, such as international matches (between England and Scotland, in 1872), the introduction of professionalism (1885), and the first full-time league (1888). Soccer was carried to continental Europe, South America, and India by British sailors and settlers.

Soccer's international governing body, the FIFA, was formed in 1904. In 1908 the sport was made a regular Olympic Games event. Professionalism arrived in continental Europe in the 1920s and in South America less than a decade later. By 1930 the interest in soccer was high enough to ensure the success of the first World Cup, for which 13 countries competed.

Soccer arrived in the United States during the late 19th century, but its first widespread nationwide sanction did not take place until the National Collegiate Athletic Association (NCAA) recognized (1959) it as an official collegiate sport with a national championship tournament. Soon after the formation (1967) of the North American Soccer League (NASL), the sport became the fastest growing in the United States for young people.

The Modern Game

No team sport approaches soccer's popularity in both Europe and South America. The professional leagues on these continents play from fall through spring in domestic competition, after which the top teams take part in international "cup," or tournament, play. The European Cup (1955) is the most prestigious in Europe and has been dominated since the 1960s by clubs from the Netherlands, West Germany, and England. The best tournament in South America is for the Liberator's Cup (1960) and is usually won by a team from Argentina. Those two cup winners then meet for the annual World Club Championship.

Many African nations, are close to producing world-class soccer teams. The major international competitions in Africa are the African Cup of Nations, held biennally between national all-star teams, and the annual African Cup of Champion Clubs. Asia's best soccer, once in Iran, is now in Japan and North Korea.

The critical turning point for soccer in the United States was Pelé's joining the New York Cosmos of the NASL in 1975. Perhaps history's greatest player, he inspired many young people to try the game. They found it

WORLD CUP COMPETITION

Year	Championship Match	Location
1930	Uruguay 4, Argentina 2	Montevideo, Uruguay
1934	Italy 2, Czechoslovakia 1	Rome
1938	Italy 4, Hungary 2	Paris
1950	Uruguay 2, Brazil 1	Rio de Janeiro
1954	West Germany 3, Hungary 2	Bern, Switzerland
1958	Brazil 5, Sweden 2	Stockholm
1962	Brazil 3, Czechoslovakia 1	Santiago, Chile
1966	England 4, West Germany 2	London
1970	Brazil 4, Italy 1	Mexico City
1974	West Germany 2, Netherlands 1	Munich
1978	Argentina 3, Netherlands 1	Buenos Aires
1982	Italy 3, West Germany 1	Madrid
1986	Argentina 3, West Germany 2	Mexico City
1990	West Germany 1, Argentina 0	Rome

easy to learn, less injurious than U.S. football, and equally enjoyable for both boys and girls. The Soccer Industry Council of America estimates that at the end of the 1980s about 12 million Americans under the age of 19—37% of them girls—were playing organized soccer, ranking third among all sports, behind basketball (first) and volleyball. For the age group under 13, soccer participation ranked second after basketball. The NCAA administers more than 700 collegiate men's and women's teams in all three of its divisions and organizes an annual national championship tournament in each. The National Association of Intercollegiate Athletics (NAIA) also organizes an annual tournament.

For all of soccer's continued growth and popularity at the amateur level, the U.S. professional game has lived a checkered existence. The oldest professional circuit was the American Soccer League (ASL), founded in 1933, which survived for 50 years. The NASL, founded in 1967, shut down after the 1984 season.

Indoor soccer, begun in 1939, is played during the winter months in the United States by one league—the Major Soccer League, formed in 1978. Indoor soccer is played with a regulation ball by five players and a goalkeeper on a hockey-rink-like Astro Turf field surrounded with Plexiglas. The goals are also smaller than those in outdoor soccer, and substitutions are unlimited. The action is fast and continuous over four 15-minute periods and, if necessary, one overtime period.

social anthropology Social anthropology is a field of ANTHROPOLOGY concerned with the comparative study of social systems. Its method is primarily that of FUNCTIONALISM, focusing on the functions of social institutions (such as marriage, kinship, and religion), but also that of structural-functionalism, or the functional integration of social structure. Although sometimes called comparative sociology, the field is distinguished from sociology proper in its emphasis on understanding the community under study in its entirety and by its tradition of studying and comparing non-Western cultures. The French sociologist Émile DURKHEIM is regarded as one of the founders of social anthropology, particularly the theoretical framework of structural functionalism. The British social anthropologists Bronislaw MALINOWSKI and A. R. Radcliffe-Brown were among other early theorists. Later social anthropologists such as Fred Eggan and Raymond Firth have attempted to integrate historical, or diachronic, perspectives into the field's traditionally present-oriented analytic techniques.

social behavior, animal see ALTRUISM; ANIMAL BEHAVIOR; ANIMAL COMMUNICATION; ANIMAL COURTSHIP AND MATING; SOCIOBIOLOGY

social contract The social-contract theory concerns the origin of organized society, holding that the state originally was created through a voluntary agreement entered into among individuals living in an anarchical state of nature. This contract defines and regulates the relations among the members of society and between the individual and the governing authority. The social-contract theory challenged the DIVINE RIGHT of kings as the basis for a state's legitimacy and laid the foundation for theories of constitutional government.

The English philosophers Thomas HOBBES and John LOCKE and the French philosopher Jean Jacques ROUSSEAU held differing concepts of the social-contract theory. In Rousseau's state, political authority reflects the "general will" of the people.

See also: REPRESENTATION; STATE (in political philosophy).

Social Credit party The Social Credit party is the collective name of political organizations in Canada that have been particularly strong in Alberta (where the party, led originally by William ABERHART, ruled from 1935 to 1971), British Columbia (in power 1952–72 and 1975–), and Quebec (where it is known as Ralliement Créditiste). Social Credit, which had its beginnings in the Great Depression, is based on the theories of an Anglo-Scottish engineer, Clifford Hugh Douglas (1878–1952). The party originally hoped to enact a number of radical monetary measures aimed at correcting the lack of purchasing power. The intention was to provide more money to consumers to make up for what it considered deficiencies in the capitalist economic system. Some of the measures, one of which included giving citizens a $25 monthly dividend, were later invalidated by the courts. Today the party is considered more conservative than either of Canada's two major parties.

Social Darwinism Social Darwinism was a late-19th-century sociological theory that was based on the theories of biological evolution and natural selection put forth by biologists Charles DARWIN and Alfred Russel WALLACE and on social philosopher Herbert SPENCER's theory of sociocultural evolution, "survival of the fittest." The school originated with the appearance of Walter BAGE-

HOT's *Physics and Politics* (1872) and reached its most radical formulation in the works of the Austrian sociologist Ludwig Gumplowicz (1838–1909), notably in his *Der Rassenkampf* (The Racial Struggle, 1883). Bagehot sketched the historical development of social groups into nations by means of intergroup struggles; Gumplowicz formulated a universal law to the effect that all social evolution was a product of group conflict.

Social Darwinists argued that societies—like organisms—evolved by a natural process through which the most fit members survived or were most successful. The theory went hand in hand with political conservatism; the most successful social classes were supposedly composed of people who were biologically superior. Social Darwinism was also used to support imperialism—peoples who viewed themselves as culturally superior, being allegedly more fit to rule those whom they deemed less advanced. In the United States the foremost publicist of the theory was the sociologist William Graham SUMNER.

Social Gospel The Social Gospel movement, led by American Protestants of liberal theological orientation, was an attempt to bring the message and power of faith to bear on the social problems of the day. Most effective in the years 1870 to 1918, it began as a result of the economic and labor crises of the 1870s and in reaction to the economic conservatism of the churches. Pioneer leaders included Jesse Jones and Edward Rogers with their Christian Labor Union and Washington Gladden with his book *Working People and Their Employers* (1876). Walter RAUSCHENBUSCH emerged as the most effective spokesman for the movement, interpreting its economic goals in *Christianity and the Social Crisis* (1907) and its theological position in *A Theology for the Social Gospel* (1917). The movement stimulated the founding of the Federal Council of Churches in 1908. The council's Social Creed spelled out some of the practical goals of the movement, including the social and physical protection of workers, higher wages, and the abolition of child labor.

social psychology Social psychology is the study of individuals' thoughts, feelings, and behavior as they affect or are affected by other individuals. The discipline gradually developed from its 19th-century, speculative-philosophical stage—heavily influenced by Auguste Comte, Karl Marx, Charles Darwin, and Herbert Spencer—to a more scientific, 20th-century stage in which there is a preoccupation with the empirical testing of hypotheses. Researchers in the broad field of social psychology investigate such varied topics as the effects of childhood experiences on adult personality; the ways in which people influence one another through NONVERBAL COMMUNICATION; the extent to which AGGRESSION in society is traceable to violence on television; the comparative impacts on creativity of working alone and in groups; the effects of racial segregation on intergroup prejudice; and the factors that inhibit people from coming to the aid of a person in distress.

Working Methods of the Social Psychologist. A social psychologist attempts to formulate knowledge about interpersonal processes, such as those mentioned above, into hypotheses. The hypotheses must be derived from explicitly stated general principles that constitute theories about the nature of the person and of society, and they must be testable in situations that provide objective evidence regarding their validity. Without the broad integrating principles of a theory, social psychological findings would be simply an inventory of isolated relationships, and it would be impossible to generalize from the outcome of a specific investigation.

Topics Studied in Social Psychology. One major field is research on socialization practices—investigating how child-rearing practices connected with the age of weaning, adolescent initiation, number of brothers and sisters, and so on affect adult personality. Findings indicate that differences among individuals and cultural groups in preferred art forms, beliefs about the nature of illness, and the content of dreams are all affected by early social experiences. Socialization theorists also account for some of the adult differences between the sexes and among national groups in terms of differences among the groups in their early socialization experiences.

Other social psychologists study interpersonal COMMUNICATION, investigating such topics as how differences in the structure of the languages spoken in different cultures result in differences in the thought patterns of people in those societies. Sociolinguists study such topics as the role of bilingualism in intergroup conflict and the role of differences in speech patterns in separating the socioeconomic classes. Other research topics in this area include persuasive communication and nonverbal communication.

Another focus in social-psychology research is on processes of social influence through suggestion, modeling, and the mass media. Social influence is discussed in more detail in the articles CONFORMITY and PROPAGANDA.

Social psychologists also study a wide variety of topics having to do with group dynamics. Some investigate how communication in groups is affected by status differences among the members or by the length of time they have been together; others study the determinants of leadership and the effects of leadership style on group productivity and morale. Still other group theorists study how the person's creativity differs when working alone as compared with when working in a group.

A less heavily investigated topic is that of social perception, which studies such issues as the extent to which an individual's perception of the environment is selective and distorted in the service of his or her motivation and how an individual's hopes and prejudices influence what is remembered.

A particularly popular topic in this area is how people perceive one another—for example, the importance of a person's first impressions and implicit personality theories; how items of information about the other person are put together; and how motivation is attributed to another.

The area of interpersonal hostility has also received considerable attention in social psychology. Research has been done on interpersonal and intergroup hostility, investigating such topics as the effects of televised violence on fear and antisocial behavior in the viewer and the causes of intergroup hostility that lead to racial prejudice and international wars. Social psychologists also investigate how interpersonal conflicts can be resolved; for example, they study the effects of racial integration on ameliorating prejudice.

The opposite topic, interpersonal attraction, has received at least equal attention from social psychologists. A variety of factors contributing to people's liking for one another have been identified, such as similarities of beliefs, length of acquaintanceship, extent to which the one person's goals are facilitated by the other person, and the extent of the one person's liking for the other person. Studies of "good Samaritans" coming to the aid of people in distress have indicated that altruistic helping behavior is encouraged by the individual's witnessing of other people showing such behavior and by the individual's observation of the need for helping action when he or she is alone so that there is no possible diffusion of responsibility.

Theories in Social Psychology. Consistency theorists stress the human need to keep beliefs mutually consistent and in harmony with feelings and actions. Attribution theorists stress a person's need to give meaning to his or her life and environment by attributing causes and motives to the events he or she experiences. Autonomy theory stresses the person's need for a feeling of control over his or her own destiny, combined with a feeling of some measure of personal freedom. The ego-defensive theorists emphasize a person's need to maintain self-esteem by interpreting his or her own behavior and that of others in a way that will maintain his or her illusions about the self. Reinforcement theorists stress the person's tendency to behave in ways that in similar circumstances in the past have brought rewards. Modeling theorists stress the person's tendency to look to the behavior of others in order to adopt a gratifying role model for imitation.

social realism As used in art, the term *social realism* describes both a specific stylistic approach and an overall attitude toward subject matter. Like genre art, social realism aims at the unadorned depiction of the contemporary life; unlike genre, however, social realism's primary goal is not to amuse but to convince the observer of the evils of poverty, immorality, and war. Social realism differs from *socialist realism*, the communist aesthetic doctrine that art should be representational and should glorify workers in the socialist state.

Social-realist art grew out of the atmosphere of the failed Revolution of 1848 in France. Their political hopes crushed by the ensuing reactionary regime, a group of French artists expressed their social concern in realistic depictions of the barren lot of the poor. Gustave COURBET's socialist aims are clearly seen in his monumental immortalization of a country burial entitled *A Funeral at Ornans* (1849; Louvre, Paris). Courbet's canvases were judged by conservative critics to be as dangerously inflammatory as the noble peasants in François MILLET's *The Gleaners* (1857; Louvre, Paris), a work whose social-realist content was softened by sentimental overtones.

Ben Shahn's Scotts Run, West Virginia *(1937), a succinct commentary on industrialized America, protests the bleakness of workers' lives. (Whitney Museum of American Art, New York City.)*

Social-realist painting in France declined after the 1860s, at precisely the time it became important in Great Britain. Sir Luke Fildes's *Applicants for Admission to a Casual Ward* (1874; Royal Holloway College, Egham, Surrey), Frank Holl's *Newgate: Committed for Trial* (1878; Royal Holloway College), and Hubert Herkomer's *Pressing to the West* (1884; Leipzig Museum, Germany) depict grimy scenes of urban poverty. In the early 1900s the British social-realist tradition was carried on in the United States by the ASHCAN SCHOOL, whose emphasis was echoed by several major American painters after 1920. In the late 1920s and early '30s, Ben SHAHN showed laborers and other victims of the Depression as well as scenes of the Sacco and Vanzetti trial and execution; Ivan ALBRIGHT and Edward HOPPER focused on the isolation of the individual in an urbanized society.

social sciences The social sciences comprise several academic disciplines that are devoted to the study of individual and collective activities within diverse social contexts. There is disagreement over which disciplines constitute the social sciences. Those most often cited are ANTHROPOLOGY, ECONOMICS, GEOGRAPHY, POLITICAL SCIENCE, PSYCHOLOGY, and SOCIOLOGY. Although they are usually studied at postsecondary levels, some elements of the social sciences are found in SOCIAL STUDIES EDUCATION at the elementary and secondary levels. Social scientists have increasingly employed investigative and analytical techniques analogous to those used in the natural sciences.

social security Social security consists of public programs intended to protect workers and their families from income losses associated with old age, illness, unemployment, or death. The term is sometimes also used to include a broad system of support for all those who, for whatever reason, are unable to maintain themselves (see SOCIAL AND WELFARE SERVICES). In the United States the term has a more specific connotation, referring to a complex of national programs that began to evolve with the passage of the Social Security Act of 1935 and that are now administered by the Social Security Administration. The principal programs are Old Age, Survivors, and Disability Insurance (OASDI)—now officially called Retirement, Survivors, and Disability Insurance—and Hospital Insurance (HI), or MEDICARE. They provide direct payments to maintain the income of retired or disabled workers, their dependents, and their survivors and to defray some of the medical expenses of retirees and their spouses at age 65 and older.

U.S. social-security programs are financially self-sustaining in that they are funded on a pay-as-you-go basis through payroll taxes collected in equal amounts from employees and employers during the workers' years of active employment in accordance with the Federal Insurance Contribution Act (FICA). Participation in social security is compulsory, and benefits are paid as an "earned right." For these reasons, social security is a form of social insurance and is distinguished in the public mind from social welfare, or direct grants of aid to the indigent, based on need and financed by general tax revenues.

History of Social Insurance

In its modern form, the concept of social insurance may be said to have originated during the Industrial Revolution. The transformation of agrarian nations into predominantly urban, industrialized societies where most citizens worked for wages increased the economic insecurity of the individual and added greatly to the problems of the aged and the disabled. These conditions fostered the belief that society as a whole should bear at least some responsibility for the economic protection of its members. Although the degree to which countries have adopted the concepts of the WELFARE STATE varies enormously, the idea that a minimum state social responsibility exists is now almost universally accepted.

In 1883–84, Chancellor Otto von Bismarck of Germany established the first social-insurance programs, sickness insurance, and WORKERS' COMPENSATION plans supported by the compulsory contributions of workers and employers; in 1889 an old-age insurance program was added, to which the government also contributed.

Great Britain instituted a national social-insurance scheme, establishing a rudimentary unemployment and old-age insurance program in 1911. This program was greatly expanded and liberalized in 1925 and again after World War II when a program of "cradle-to-grave security," advocated by Sir William Henry BEVERIDGE, was adopted. New Zealand, under the pressure of economic hardship, adopted a sweeping social insurance and welfare plan in 1938, and Australia gradually instituted a similar program in the late 1930s and 1940s.

Social Security in the United States

The creation of a national social-security system in the United States did not come until the 1930s. The Social Security Act of 1935, passed as part of President Franklin D. Roosevelt's NEW DEAL legislative program, was intended to provide pensions for most retired commercial and industrial workers aged 65 years or more. At the same time it established a joint federal-state system of UNEMPLOYMENT INSURANCE.

Evolution of the U.S. System. Unemployment insurance developed as a joint responsibility of the states and the federal government, with the U.S. Department of Labor administering it at the national level. The OASDI program has been the principal responsibility of the Social Security Administration, which replaced the original Social Security Board in 1946 and became part of the newly created U.S. Department of Health, Education, and Welfare in 1953 (reorganized in 1979 as the Department of Health and Human Services). Headquartered in Baltimore, Md., the administration maintains ten major regional offices and many district and branch offices throughout the country.

The Social Security Act of 1935 provided retirement benefits only to retired workers themselves. In 1939, however, before any benefits had been paid, the first of numerous extensions to the system provided benefits for survivors and dependents. Later extensions included several classes of workers not covered under the original law.

The year 1957 saw the introduction of the national Disability Insurance (DI) program, under which a separate fund was established to provide cash benefits to workers over age 50 who become totally and permanently disabled. In 1965, Medicare was introduced, providing medical benefits for those over 65 and creating yet another social security fund to finance them. (In 1965, Congress also established the separate MEDICAID program.) In 1974 the Social Security Administration established the federal Supplemental Security Income (SSI) program, which took over responsibility from state-administered programs for providing aid to the blind, the disabled, and the indigent aged.

Contemporary Issues in Social Security. Through the years of the system's development, the level of benefits was gradually increased in an effort to keep pace with inflation. Retired workers, their dependents, and their survivors were receiving about $152 billion annually from the Old Age and Survivors Insurance (OASI) portion of the program by the mid-1980s. Disability Insurance was dispensing about $18 billion to disabled workers and their dependents, and about $41 billion in medical benefits was being provided under the Medicare program, with all of these totals increasing rapidly. The system covered more than 90% of the jobs in paid employment.

Benefits are financed by a payroll tax that rose from a rate of 2% at the inception of the program to more than 13% by the early 1980s. The taxable wage base, or maximum amount of earnings that can be taxed, is escalating as well, since the ceiling is linked to the growth in wages.

As a result of the rapid inflation, slow economic growth, and high unemployment that characterized the late 1970s, the fund experienced an increasing gap between tax receipts and outlays. In 1982, for the first time, the retirement fund borrowed money from the disability and the hospital funds to pay benefits. In 1983, Congress approved changes in the social security law designed to restore the solvency of the system. The new law accelerated the tax rate increases scheduled for 1985 and 1989 and raised the tax on the self-employed to a level equal to 100% of the combined employer-employee rate. On the benefit side, a portion of the Social Security benefits received by high-income beneficiaries began to be taxed.

For most workers, benefit amounts are based on covered earnings averaged over 20 years. Benefits are not related strictly to earnings, however; the benefit formula is weighted heavily in favor of low-income workers, assuring them of a higher percentage of their preretirement earnings than high-wage workers. Workers with dependent spouses also receive additional benefits, regardless of the latter's employment history. The Social Security program thus combines the insurance objective of wage replacement with welfare concerns.

Equity versus Adequacy. The 1935 Social Security Act attempted to set up a system under which workers would receive at least as much in benefits as they had contributed. This goal was considered crucial to public acceptance of a compulsory program. In a social insurance plan, however, where universal and compulsory protection is the goal, individual equity may be deemphasized in favor of social adequacy—a standard of living below which it is felt no one should fall. In cases where any individual's contributions do not entitle him or her to the socially desired level of benefits, individual equity and social adequacy conflict.

The 1939 amendments to the Social Security Act resolved the conflict in favor of social adequacy, because the needs of millions of the elderly were not being met by the states' old-age assistance programs. At that time the 1935 principle of a fair rate of return was weakened, and benefits were based on average earnings during a shorter period of coverage than the original base of lifetime contributions.

The Problem of Funding. The conflict between equity and adequacy has given rise to controversy about whether social security benefits should continue to be financed exclusively by the payroll tax or whether some portion of the program should be funded by another source of revenue, such as the personal income tax.

Many consider the payroll tax regressive, that is, excessively burdensome to low-income workers, because they contribute a greater share of their income than highly paid people. Substantial increases in the taxable wage base, however, have mitigated the regressivity of the payroll tax.

The choice of whether to rely exclusively on the payroll tax or to introduce other types of financing also involves questions about the role of social security and the effect that a change in financing might have. Some persons fear that the use of general funds would lead to excessive expansion of social security at the expense of other government programs. Others are even more opposed to the change because they believe that the program should be divested of its welfare function and that benefits should be based entirely on the earnings record of each participant.

Important factors in the debate are the growing burden imposed by the payroll tax itself and the serious financial problems expected to confront the Social Security system after the turn of the century. For example, in the early 1980s there were about 30 beneficiaries per 100 covered, contributing workers. By the year 2025, the number of beneficiaries is expected to grow to more than 50 per 100 workers. Under a pay-as-you-go system, an increase in the ratio of beneficiaries to workers implies an inevitable matching increase in taxes. It has been calculated that the combined expenditures for both OASDI and Medicare in the year 2025 might require a payroll tax as substantial as 22%.

social structure and organization Social structure in human groups means an orderly, fixed arrangement of parts making up an integral whole: a society, a community, or an institution. Social organization refers to the dynamic efficiency of a structure in relation to the concerted actions of group members or to their enduring common purposes.

The terms are sometimes used interchangeably. Concrete planning and task-oriented activities, however, are best considered as social organization. Statements about the structure of a group are normally made in abstract terms and refer to the similarities and differences members perceive among themselves and that provide them with their most important social distinctions.

Social Structure

Social structure may be studied through the development of models representing typical cases. Two such models picture an egalitarian and a stratified society.

Egalitarian Society. It is not hard to imagine a small, isolated, and homogeneous society comprising a few hundred (or thousand) families, each with its own domicile, each getting its own food and clothing from nature, and recognizing no chiefs. Two sorts of rules generate egalitarian societies: one set governs the internal structure of the family groups; the other regulates their interrelationships. Family-group rules are related to a cycle of development through one full generation to the establishment of the next. Rules allocate authority, work, and privilege according to sex, age, and status. In particular, incest is strongly prohibited. Provision is made for the dissolution or reconstitution of the group when a member dies. The headship may belong to a man or a woman, or it may be shared. Sons, daughters, or both may be obliged to shift residence when they marry.

The second set of rules governing egalitarian society pertains to those concerns a family on its own cannot cope with, such as the regulation of marriage and fosterage, torts and property rights, intergroup hostility, and cooperative alliance. Typical of egalitarian societies is the use of clan membership to help regulate public life: rules of descent determine the clan of each person at birth, and clan rules in turn define property and hunting rights, ceremonial standing, and the choice of partners in marriage.

Egalitarian societies have subsistence economies, making the family an all-purpose institution. Hunting-gathering people usually have a band structure, combining several families and attached individuals in small, nomadic communities, or communities that follow the seasonal movement of game, suited to survival in a given region. Among the best-known examples of egalitarian structure are the Eskimo, or Inuit, as hunters; the Pueblo of Arizona and New Mexico, as gardeners; and the Nuer of the Eastern Sudan, as pastoralists.

Stratified Society. Contemporary urban-industrial societies are most conveniently studied at the town or village level, where stratification shows up most clearly. A few decades ago, towns in the U.S. South normally exhibited the two major types of stratification, ethnic and CLASS. In the North ethnic stratification—for example, the low status of the Boston Irish early in this century—would appear as an initial response to immigration but gradually die away. In the South the color bar was both more explicit and more durable, being backed by racist doctrines. Class differences were also pronounced. Class lines, however, are never absolute barriers, while CASTE is.

For caste the cardinal rule is that individuals of different castes must not be members of the same family. The class barrier entails a contrary rule: regardless of separate class origins, all members of one family belong to the same class. In order to maintain the cardinal rule of caste, offspring of the sexual union of whites and blacks in the South were always deemed to be black. Similarly in India, when a Brahman woman has a child by a man of lower caste, she is evicted from her household for bringing a stranger into the midst of her family.

Because differences accruing within a family through marriage or adoption across class lines must socially disappear, the class identity of a family must be read from its circumstances, not its history. One significant counter-criterion may be name—that is, family reputation built up over time, which gives a claim to STATUS. Even in stable communities, however, the main criteria of class tend to be current assets and long-term expectations—wealth and connection to it, education and profession, and the moral qualities associated with solvency.

Class is associated with competitive individualism and social mobility, while caste militates against these qualities of the open society. The criteria of class standing are multiple. The more open the class system is, the less exact are the lines that may be drawn—but this does not mean that class disappears. The greater the competition for class and position, the more steeply stratified a society may become, although nominal class identities may be vague.

Social Organization

Any attempt to understand the social structure of an industrial society through community studies must be supplemented by study of companies and BUREAUCRACIES, schools and universities, churches, voluntary associations, and political parties and movements. Each of these organizations incorporates structural principles characteristic of the society, but each in turn has its effect on the general structure. For instance, the recent appearance of powerful multinational industrial organizations has tended to homogenize the structure of the modern capitalist world.

Changes of structure may occur with revolutionary violence or by incremental shifts. Few social structures are so brittle that they will not bend before breaking under stress; all social structures do resist change in the short run, however. Some structures remain stable because they function well with respect to both individuals' needs and the larger context, but repressive institutions may be maintained in spite of the constraints they impose, and the most satisfactory institutions may be swept away by external forces.

Social structures do not maintain themselves in the face of ideological and ethical revolution. A Victorian family structure could never survive in the moral climate of the modern suburb. Historically, new religions and new social structures have been firmly associated, whether in modern China or ancient Rome. The study of social structure may offer a comprehensive view of a society, including even its ideas and moral beliefs.

social studies education

social studies education The concept of social studies in the United States was developed in the early decades of the 20th century as a way of improving citizenship education. Many educators believed that history, geography, and civics—as traditionally taught at elementary and secondary levels throughout the 19th century—were inadequate to prepare students for citizenship in a society that had been radically altered by immigration, industrialization, and urbanization. In the 1920s educators designed a social studies curriculum that was widely adopted. This curriculum consisted of world (mostly European) history, U.S. history, civics, geography, and social problems.

While a majority of teachers and scholars believed that preparation for citizenship, with emphasis on decision making, was the most important goal of social studies, other aims included inculcating patriotism, democratic attitudes, desirable moral traits, and respect for all persons. Social studies education has tended to transmit mainstream cultural values, including respect for authority, obedience to the law, and appreciation of the U.S. democratic heritage.

The curriculum that was first accepted by most U.S. schools continues, with some changes, to the present. History remains dominant, although a sampling of such social sciences as sociology, anthropology, political science, economics, psychology, and area studies are also included.

In the 1960s, experimental social studies projects were designed to teach the inquiry modes of the social sciences. Despite initial enthusiasm, however, community opposition and lack of support by teachers caused these curriculum experiments to fail. In subsequent years, topics such as the concerns of minority groups and women and other social issues were increasingly included in the social studies curriculum.

social and welfare services Public-assistance programs, commonly called "welfare," provide cash or in-kind benefits for particular categories of the financially needy. Public provision for the needy in the United States remains strongly influenced by the POOR LAWS of England, which were highly punitive and stigmatized recipients of public charity. U.S. welfare programs grew significantly in the decades following World War II, but increases in welfare costs during the 1960s and '70s brought into question the extent and quality of public assistance. In the early 1980s the Reagan administration reduced welfare expenditures and suggested turning responsibility for welfare funding over to the states. The cuts in federal funding did in effect place the responsibility for maintaining funding levels for some welfare programs on the states themselves—and, in some cases, on the larger cities.

Major U.S. Programs

The main public assistance income benefit program is Aid to Families with Dependent Children (AFDC). Three other programs are often included when "welfare" is referred to: Emergency Assistance (EA), General Assistance (GA), and Supplemental Security Income (SSI). AFDC and EA are paid for by a combination of federal, state, and local funds. GA is funded by the states and localities alone. AFDC, EA, and GA are administered by states and localities, which establish their own need standards and benefit levels. These vary widely, and as a result great disparities exist in assistance levels from state to state. The federal government funds and administers SSI, although 27 states provide additional SSI payments above the federal level. Applicants for all programs are subject to a means test, which determines eligibility according to income and assets.

Aid to Families with Dependent Children (AFDC). The largest and most costly of all the income welfare programs, AFDC is intended to cover the minimum costs of providing care for dependent children. Such aid is available for children in need who have lost the support of a parent because of death, prolonged absence, or incapacity and for the parents or guardians with whom the children live.

First enacted in Illinois in 1911, legislation providing funds to enable widows and deserted women to care for their children had been passed in 19 other states by 1913. Aid to Dependent Children was included in the Social Security Act (1935) mainly to serve widows with children in their homes as a joint federal-state assistance program, under which the federal government provides matching grants to the states, and each state administers its own program. Because no federal minimum benefit level has been established, benefits vary extensively from state to state. To qualify for AFDC in any state, children must be less than 18 years of age, or less than 19 and in high school; lack parental support; and be financially needy. Twenty-seven states provide benefits under stringent criteria when either parent is unemployed (AFDC-UP).

Supplemental Security Income. Federal-state programs funded by grants from the federal government were enacted for old-age assistance and aid to the blind as part of the Social Security Act of 1935. Aid to the Permanently and Totally Disabled was enacted in 1951. In 1974, SSI replaced these state-administered programs. It provides a uniform, federally administered minimum cash income to aged, blind, and disabled people.

General Assistance. General assistance is available to people who are ineligible for federal categorical programs. Eligibility is based on state-defined need and verified by a means test that considers all income and assets, including, in some states, the possibility of aid from relatives. Benefits in 32 states range from cash payments to groceries and shelter and are administered by state or local authorities.

Emergency Assistance. In some states assistance is provided for specified emergencies to adults eligible for SSI and to destitute families with children under age 21. Eligible adults must experience sudden emergencies that deprive them of the means to stay alive and healthy. Benefits are in cash, in kind, or in voucher form.

Additional Programs. The public-assistance system also includes housing allowances; MEDICAID; the FOOD STAMP PROGRAM; school meals; welfare-to-work programs, which provide job placement, training, or public-service employment; an earned-income-tax credit for low-income workers with a child in the household; and the Low Income Energy Assistance program, which supplies at a minimum one supplementary fuel or utility payment during the heating season to certain public-assistance and SSI recipients and other low-income persons. Social services include DAY-CARE CENTERS, foster and protective care, family planning, and services to the mentally retarded and to drug and alcohol abusers.

Criticisms and Reforms

By the late 1980s welfare costs per annum topped 30 billion, or 3.1% of the federal budget. Some critics charge that welfare costs are excessive, that fraud is widespread, and that welfare undermines the work ethic. Other critics argue that benefit levels are inadequate, that the system has too many inequities, that the system is inefficient, and that costs are increased through overzealous surveillance and the use of means tests.

Whether it is viewed as an unnecessary drain or an inefficient necessity, however, public assistance cannot be separated from larger social developments. Since World War II the number of people on the AFDC rolls has increased because of population growth, family breakdown, periods of high unemployment, a shrinkage in the number of jobs for unskilled labor, and more female-headed one-parent families.

Costs are also influenced by the nature of the public-assistance regulations themselves. In the case of AFDC, they have encouraged family separations and discouraged single mothers from marrying or remarrying. When an employed recipient earns or saves more than is allowed by regulations, some or all benefits are taken away. Thus some working AFDC mothers have lost subsidized day care for their children and have had to leave their jobs or have had their benefits reduced to a point below what they would receive if they were unemployed. Some regulations and elegibility requirements thus operate as work disincentives.

Concurrent with the perennial debate over welfare, many Democrats in Congress, civil rights organizations, advocates for the poor, and churches urged the continuance of federally backed programs to help deprived persons. In recent years a consensus developed in Congress favoring reforms that would encourage welfare recipients to find jobs and to free themselves from long-term dependence.

The major welfare-reform bill passed by Congress in September 1988 requires that single parents on welfare with children over 3 years old must participate in a Job Opportunities and Basic Skills (JOBS) program offering education, training, and work. One adult in each two-parent welfare household must participate in a job search. If no work is found, he or she will be required to work 16 hours per week in a state-organized job or work toward a high school diploma. States are to concentrate their resources on young parents lacking a high school education, long-term recipients, and families with older children. JOBS participants would receive transportation, Medicaid, and child-care help for at least a year. All states are now required to pay cash benefits to two-parent welfare families. States are also expected to intensify child-support enforcement from noncustodial parents (including wage withholding under court-awarded rulings) through improved use of computerized systems. Congress gave the states until Oct. 1, 1990, to put the basic welfare-to-work provision into place, so that the states can pass their own laws in order to be eligible for federal grants for welfare.

Public assistance remains a politically charged issue. The subject involves how society views the poor and vulnerable, the complex social and economic problems public-assistance recipients reflect, and the degree to which the nation will tolerate poverty amid plenty.

social work The field of social work has a dual purpose: that of helping individuals, families, groups, and communities with specific problems to function effectively in society, and that of encouraging the constructive involvement of society in caring for its members. Social workers aid the needy in obtaining food, shelter, and other essential resources and services; they counsel and provide psychotherapy for individuals, families, and groups; they plan and coordinate social services for communities and groups; and they participate in governmental decisions to improve social conditions.

Methods and Training. Traditionally, social work has been organized by three principal methods. Social casework provides individualized services to persons and families in order to help them cope with physical, mental, or social problems. Social group work aims at cooperative problem solving and mutual aid, personal growth and development, the interrelationships of members, and influencing factors external to the group. Community organization and social planning includes as its goals the organization of community welfare resources, cooperative planning of community programs, and improvement of existing policies for human welfare. These traditional methods are often merged in practice.

By the late 1980s there were 98 graduate schools of social work in the United States and 13 in Canada; 355 B.S.W. (baccalaureate) programs in the United States and 18 in Canada; and 46 doctoral programs in the United States. Educational standards are set by the Council of Social Work Education, which accredits baccalaureate and master's degree programs in the United States. Canada has a similar council. In the United States, the National Association of Social Workers certifies social workers who have achieved certain professional standards. Forty-four states, the District of Columbia, the Virgin Islands, and Puerto Rico also license or certify professional social workers.

Origins of Social Work. Not until the 19th century, when industrialization and the increasing urbanization of society produced complex social needs and problems in Europe and North America, did social work begin to develop as an organized activity. Charitable organizations, such as the New York Association for Improving the Conditions of the Poor (founded 1843) and the Charity Organization Societies (founded 1877), attempted to meet the social needs of U.S. cities by training and supervising volunteers to visit the poor, the unemployed, the disabled, and others in difficulty. These so-called friendly visitors tried largely through moral persuasion to provide alternatives to dependence on public relief and to help people become economically self-sufficient.

In offering direct aid to individuals and families, the charity societies were the forerunners of social casework and family-service agencies. Efforts in social group work began with the establishment in urban slums of settlement houses, in which volunteers lived and worked with local residents to improve neighborhood conditions. First developed in England with the founding (1884) of London's Toynbee Hall, settlement houses soon appeared in continental Europe and the United States, notably at HULL HOUSE (1889) in Chicago.

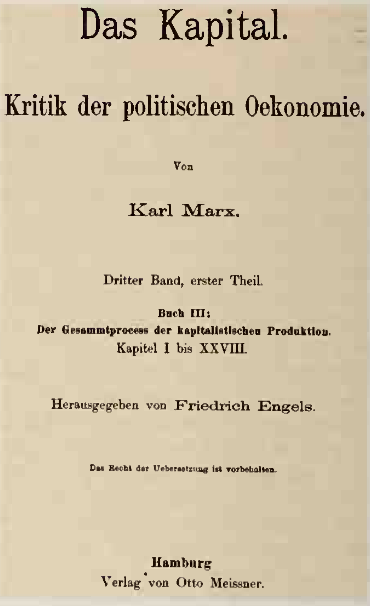
Social Work in the United States. The first organized U.S. training program for social work was sponsored (1898) by the New York Charity Organization Society. By 1919 the Association of Training Schools for Professional Social Work had 17 member schools, and social workers devoted themselves to such areas as medical, psychiatric, child-guidance, school, and family social work. The American Association of Social Workers, established in 1921, merged (1955) with various specialized groups to form the National Association of Social Workers, today the umbrella organization of the profession.

Virtually all U.S. social welfare was sponsored either by private organizations or by state or local governmental agencies prior to the 1930s. With the economic depression, however, the federal government stepped in to create a number of large-scale, ongoing SOCIAL AND WELFARE SERVICES, such as Aid to Families with Dependent Children and old-age insurance, primarily under the auspices of the Social Security Act (1935). This massive shift in responsibility for social-service programs was accompanied by a steady growth in the number of social workers employed nationwide.

More than a half million social workers were employed in the United States by the late 1980s. Among their fields of service are: families, children, and youth; the elderly; health; housing; mental health; civil rights; physical handicaps; developmental disabilities; education; neighborhood and community development; crime and delinquency; income security and employment; and religious institutions. They serve such population groups as women; religious, racial, and ethnic groups; migrants; immigrants; veterans; AIDS victims; and single parents. Included among the problem areas are substance abuse, emotional and physical problems, family discord and violence, community deterioration, and homelessness. About 40 percent of all U.S. social workers provide social services through state, county, or municipal governmental agencies, and a large number are employed in the private voluntary sector.

Outstanding contributions to social-reform efforts have been made by such American social workers as Jane Addams, Nobel Peace Prize recipient in 1931; Lillian Wald, founder (1893) of New York City's Henry Street Settlement and visiting nurse service; Florence Kelley, advocate for consumer and labor legislation; Harry L. Hopkins, advisor to President Franklin Roosevelt and organizer of New Deal–ERA programs; and Frances Perkins, Roosevelt's secretary of labor.

The first volume of Karl Marx's Das Kapital *(1867), published nearly 20 years after his* Communist Manifesto *(1848), detailed the social and economic theories that rapidly came to dominate socialist thought. Marx's emphasis on the inevitable direction of historical development contrasted with the perspective of the earlier utopian socialists.*


Das Kapital.

Kritik der politischen Oekonomie.

Von

Karl Marx.

Dritter Band, erster Theil.

Buch III:
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Kapitel I bis XXVIII.

Herausgegeben von Friedrich Engels.

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socialism The term *socialism* is commonly used to refer both to an ideology—a comprehensive set of beliefs or ideas about the nature of human society and its future desirable state—and to a state of society based on that ideology. Socialists have always claimed to stand above all for the values of equality, social justice, cooperation, progress, and individual freedom and happiness, and they have generally sought to realize these values by the abolition of the private-enterprise economy (see capitalism) and its replacement by "public ownership," a system of social or state control over production and distribution. Methods of transformation advocated by socialists range from constitutional change to violent revolution.

Origins of Socialism

Some scholars believe that the basic principles of socialism were derived from the philosophy of Plato, the teachings of the Hebrew prophets, and some parts of the New Testament (the Sermon on the Mount, for example). Modern socialist ideology, however, is essentially a joint product of the 1789 French Revolution and the Industrial Revolution in England—the word *socialist* first occurred in an English journal in 1827. These two great historical events, establishing democratic government in France and the conditions for vast future economic expansion in England, also engendered a state of incipient conflict between the property owners (the bourgeoisie) and the growing class of industrial workers; socialists have since been striving to eliminate or at least mitigate this conflict. The first socialist movement emerged in France after the Revolution and was led by François Noël Babeuf, Filippo Michele Buonarrotti (1761–1837), and Louis Auguste Blanqui; their insurrection in 1796 ended in failure. Other early socialist thinkers, such as the comte de Saint-Simon, Charles Fourier, and Étienne Cabet in France and Robert Owen and William Thompson (*c.*1785–1833) in England, believed in the possibility of peaceful and gradual transformation to a socialist society by the founding of small experimental communities; hence, later socialist writers dubbed them with the label *utopian*.

The Emergence of Marxism

In the mid-19th century, the German thinkers Karl Marx and Friedrich Engels produced what has since been generally regarded as the most sophisticated and influential doctrine of socialism. Marx believed that human beings, and particularly workers, were "alienated" in modern capitalist society; he argued in his early writings that the institution of private property would have to be completely abolished before the individual could be reconciled with society and nature. His mature doctrine, however, worked out in collaboration with Engels, struck a harder note.

The first important document of mature Marxism, the Communist Manifesto (1848), written with Engels, asserted that human history is essentially the history of social classes locked in conflict. There has in the past always been a ruling and an oppressed class. The modern, or bourgeois, epoch, characterized by the capitalist mode of production with manufacturing industry and a free market, would lead according to Marx and Engels to the growing intensity of the struggle between capitalists and workers (the proletariat), the latter being progressively impoverished and as a result assuming an increasingly revolutionary attitude. Capitalism, however, as Marx claimed, would soon and necessarily grind to a halt, resulting in the forcible overthrow of the existing system and its immediate replacement by the "dictatorship of the proletariat." This dictatorship would soon be superseded by the system of socialism, in which private ownership is abolished and all people are remunerated according to their work, and socialism would lead eventually to COMMUNISM, a society of abundance characterized by the complete disappearance of the state, social classes, law, politics, and all forms of compulsion. Under this ideal condition goods would be distributed according to need, and the unity of all humankind would be assured because of elimination of greed.

Varieties of European Socialism

Marxist ideas made a great impact on European socialist movements. By the second half of the 19th century socialists in Europe were organizing into viable political parties with considerable and growing electoral support; they also forged close links in most countries with trade unions and other working-class associations. Their short-term programs were mainly concerned with increasing the franchise, introducing state welfare benefits for the needy, gaining the right to strike, and improving working conditions.

Moderate Socialism. Ideas other than those of Marx were at this time also becoming influential. Such ideas included moderate socialist doctrines, for example, those of the FABIAN SOCIETY in England; those of Ferdinand LASSALLE in Germany; and of Louis BLANC in France. These moderates sought to achieve socialism by parliamentary means and by appealing deliberately to the middle class. Their doctrines, collectively known as social democracy, did not, like Marxism, look toward the complete abolition of private property and the disappearance of the state but instead envisaged socialism more as a form of society in which full democratic control would be exercised over wealth, and production would be controlled by a group of responsible experts working in the interests of the whole community. The achievement of socialism was seen by social democrats as a long-term goal; socialism would be the triumph of common sense, the inevitable outcome of LIBERALISM, the extension of democracy from politics to industry.

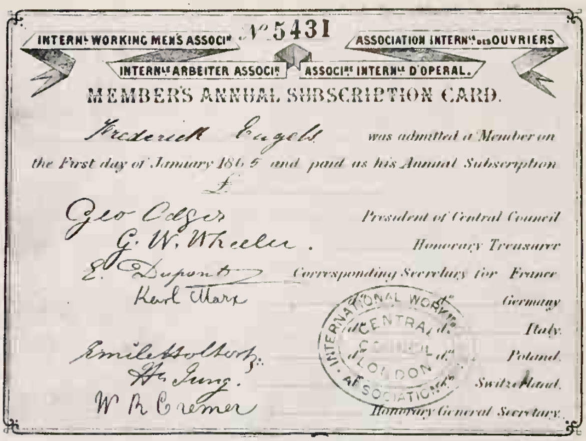
Beatrice and Sidney Webb, whose leadership in the Fabian Society did much to shape British socialism, devoted their lives to pioneering historical research and social activism.

Vladimir Ilich Lenin, revolutionary leader and first head of the Soviet state, influenced Marxist socialism through his theory of a vanguard revolutionary party and his leadership of the Bolsheviks.

CHRISTIAN SOCIALISM espoused moderate social democracy, emphasizing the central message of the church in social ethics, notably the values of cooperation, brotherhood, simplicity of tastes, and the spirit of self-sacrifice.

Radical Socialism. On the other hand, many doctrines and movements were decidedly more militant than Marxism. Anarchists (see ANARCHISM) were intent on immediately overthrowing the capitalist state and replacing it with small independent communities. Unlike the Marxists, whom they bitterly criticized, anarchists were against the formation of socialist parties, and they repudiated parliamentary politics as well as the idea of revolutionary dictatorship. SYNDICALISM, an offshoot of anarchism, was a movement of militant working-class trade unionists who endeavored to achieve socialism through industrial action only, notably by using the weapon of the general strike. Their doctrine was similar to Marxism in that they also believed that socialism was to be achieved only by and for the working class, but unlike the Marxists they rejected the notion of a future centralized socialist state. Syndicalist ideas also had intermittent success in the British and American trade union movements, for example, the INDUSTRIAL WORKERS OF THE WORLD.

In Russia, where it was impossible to organize openly a popular socialist movement under the tsarist regime, socialism became mainly the ideology of young militant intellectuals whose favored means of furthering the cause were secret conspiracies and acts of individual terrorism. Debate raged between those who believed in the native socialist ethos of the Russian village community and those who wanted to adopt Western ideas of moderniza-



INTERNL. WORKING MEN'S ASSOCIN. No 5431 ASSOCIATION INTERNLE. DES OUVRIERS
INTERNLE. ARBEITER ASSOCIN. ASSOCINE. INTERNLE. D'OPERAI.

MEMBER'S ANNUAL SUBSCRIPTION CARD.

Frederick Engels was admitted a Member on the First day of January 1865 and paid as his Annual Subscription £

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Friedrich Engels's membership card for the International Workingmen's Association includes Karl Marx among its signatories. Divided by doctrinal disputes and personality conflicts, the association collapsed (1876) twelve years after its founding.

tion. The latter party, which eventually emerged victorious, soon came under Marxist influence. Among its adherents was V. I. LENIN, who emerged at the turn of the century as the leader of a small but dedicated group of "professional revolutionaries," the Bolshevik (see BOLSHEVIKS AND MENSHEVIKS) wing of the illegal Russian Social Democratic Workers' party. Lenin worked out the theory of the proletarian vanguard, that is, the Communist party, which is destined to lead the masses toward socialism, irrespective of the masses' present inclinations.

Schism and Controversy

Throughout the 19th century the socialist movement was beset by a number of ever-deepening conflicts and doctrinal controversies.

The Internationals. The International Workingmen's Association (First International; see INTERNATIONAL, SOCIALIST), founded in 1864, was expected to achieve unity among various socialist and militant trade union organizations, but it came to its demise soon after the suppression of the COMMUNE OF PARIS (1871).

The Second International (1889–1914) was dominated by the largest socialist parties then in existence, the French—led by Jean JAURÈS, Jules Guesde (1845–1922), and Paul Lafargue (1842–1911)—and the German—led by August BEBEL, Karl Johann KAUTSKY, and Wilhelm Liebknecht (see LIEBKNECHT family). Their spokespersons emphasized the need to foster international solidarity among the mass of the working class and thus to avert the threat of a major war in Europe. This effort proved singularly unsuccessful: NATIONALISM in 1914 and later proved a much stronger mass emotion than socialism, and apart from a few exceptions, socialist movements supported the war effort of their respective governments. As a result of the general conflagration in 1914 the Second International disintegrated and therewith also the hopes of socialist unity.

Revisionism. Another important controversy broke out in the 1890s within Marxism, involving the German Social Democratic party. This party was divided then between a militant revolutionary left wing, an orthodox center that held to the classical Marxist doctrine of economic determinism, and a right wing moving rapidly toward a position of open reformism. The right wing had as its most renowned representative Eduard BERNSTEIN.

Bernstein repudiated the notion of violent revolution and argued that conditions in civilized countries such as Germany made possible a peaceful, gradual transformation to socialism. He sought to reinterpret Marxist doctrine in the light of fresh advances made in economic science, such as those also embraced in Fabian doctrine, and argued that socialism was compatible with individual economic responsibility. Bernstein asserted the need for socialists to concentrate on immediate tasks instead of ultimate and remote objectives; the movement, he wrote, was everything; the goal, nothing.

This doctrine, henceforward called revisionism, immediately became the subject of bitter attacks by the revolutionary left wing, represented above all by Rosa LUXEMBURG, which on this issue was supported by the orthodox center and its principal theorist, Karl Kautsky. The terms of the debate on revisionism centered on the facts, noted by Bernstein, of considerable improvement in the living standards of the working class, its resultant political integration in the constitutional state, the purely reformist stance of trade unions, and the virtual absence of any desire for a radical change on the part of the great majority of workers.

The opponents of revisionism, while acknowledging these tendencies, argued that material improvements were insufficient and ephemeral. They felt that if the working class and its organizations accepted the constitutional state they were merely postponing indefinitely the change to socialism. According to them, the principal tasks of the socialist leader are to arouse dissatisfaction with existing conditions and to reemphasize constantly the worth of the ultimate goal. The arguments on both sides continue today with only slight changes in the debate between reformist and revolutionary socialists everywhere.

Marxist Socialism Today

Modern socialism owes its shape and fortune at least as much to secular events as to the continuing attraction of its various doctrines. The major upheavals caused by two world wars greatly contributed to the success of the Russian (1917) and Chinese (1949) revolutions, and the governments of these two powerful countries thereafter endeavored by diverse means to spread the Marxist revolutionary doctrine further afield. Indigenous Marxist movements also succeeded in gaining and maintaining power in Cuba (1959) and Nicaragua (1979). During most of the 20th century, Marxist socialism has meant the dictatorial rule of the Communist party, intensive industrialization, central state direction of the economy, and the collectivization of agriculture. These were accompanied, particularly during the dictatorship of Joseph STALIN in the USSR, by a reign of terror and the general absence of individual freedom. The Stalinist system, though shorn of some of its worst brutalities, essentially remained in place until the rise to power of Mikhail GORBACHEV in 1985. In a few short years Gorbachev's policies of GLASNOST (openness) and PERESTROIKA (restructuring) brought rapid liberalization to the USSR and Eastern Europe, fundamentally altering the accepted picture of Marxist socialism in the process. As the Soviet regime loosened its grip the countries of Eastern Europe threw off the Communist governments that had been imposed on them after World War II. In the USSR itself the Communist party renounced its dictatorial control, and Marxist theorists repudiated the long-cherished doctrines of Leninism with bewildering speed.

European Social Democracy

In Western Europe, despite the presence of large Marxist parties (as in Italy and France) and the Marxist influence among intellectuals, socialism is still principally represented by widely based social democratic and labor movements, which generally enjoy the active support of trade unions. The social democratic parties of Sweden, Great Britain, France, and (West) Germany in particular governed for lengthy periods during the postwar era, gaining political power through constitutional means and fully accepting the principles of parliamentary liberal democracy. Their programs have relied on the expedients of progressive taxation, deficit financing, selective nationalization, the mixed economy, and vast welfare programs in order to bring about socialism; their political success has depended on considerable middle-class support.

The Social Democratic party (SPD) in Germany, although at one time the citadel of orthodox Marxism, has since 1959 been a purely reformist party, abandoning its original goals. The British LABOUR PARTY, socialist in its aims, has never had any serious doctrinal or organizational links with Marxism, although its powerful left wing consistently advocates radical policies. A dispute with the leftists prompted a group of Labour moderates to secede (1981) and found the Social Democratic party, which later merged (1988) with the Liberal party to form the Social and Liberal Democrats. The French Socialist party, which has abandoned its orthodox Marxism, allied itself with the Communists during the 1960s, but under the leadership of François MITTERRAND, it won the presidency on its own and gained a majority in the National Assembly in 1981. In the same year, the Greek Socialists came to power under Andreas PAPANDRÉOU, and in 1982, Felipe GONZÁLEZ MARQUEZ formed Spain's first Socialist government since the Spanish Civil War. Bettino CRAXI became Italy's first Socialist premier, heading a coalition government from 1983 to 1987.

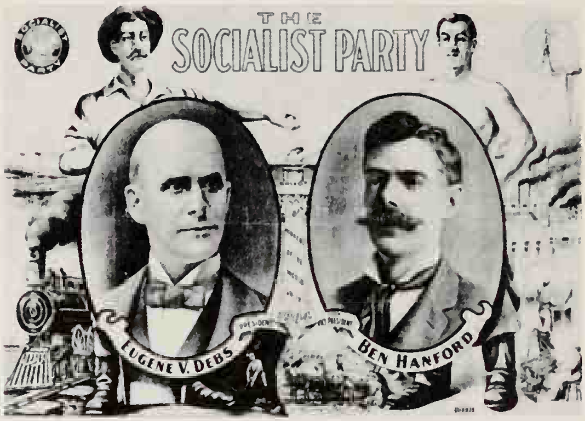
The French Communist party was long known for its subservience to the USSR and its rigid Stalinism. The Italian Communist party, on the other hand, has relied on an indigenous Marxist tradition associated mainly with the teaching of Antonio Gramsci, one of the party's founders, who is widely regarded as one of the most significant of European Marxist thinkers. The Italian party, the largest Communist party in Western Europe, has frequently obtained the highest percentage of the popular vote in Italy's parliamentary elections, and has continuously governed a number of Italian municipalities.

A British Labour party campaign poster, dating from Britain's post-World War I economic slump, promises a bright future for the worker. The reformist Labour party gained substantial popular support during the early 1920s and formed its first minority government in 1924.

During the 1970s the Italian Communists under Enrico Berlinguer, the French Communists under Georges Marchais, and the Spanish Communists under Santiago Carillo embraced a doctrine known as Eurocommunism. The Eurocommunists, breaking not only with Stalinism but with some aspects of the Leninist tradition, began moving toward full acceptance of parliamentary democracy and the multiparty system, in many ways prefiguring the *glasnost-perestroika* reforms that dramatically changed the Communist world in the Gorbachev era. To the left of the Communists were a number of new groups of militant revolutionaries, such as West Germany's Red Army (Baader-Meinhof) Faction and Italy's Red Brigades, which carried out campaigns of abduction, subversion, and terrorism in the 1970s and '80s.

Socialism in the United States

In the United States no socialist movement has ever held a very large following. Socialism has not taken a firmer root in the United States for several reasons, of which the country's cultural traditions and its wealth in natural resources are the most important. Whereas in Europe the distribution of wealth was a pressing problem, facilitating the rise of socialist movements, in the United States the moving "frontier" meant the constant creation of new land and wealth and its accessibility for those endowed with initiative and a spirit of individual enterprise. Thus in the United States even radical thinkers have tended to be "individualists" and "anarchists," rather than socialists. In this development the country's tradition of republican self-government and its ethos of egalitarianism and democracy also played a decisive role. LABOR UNIONS, for the most part, have concentrated on the achievement of high-



A campaign poster for the U.S. Socialist party promotes the 1904 presidential ticket. Organized during the 1890s and led by Eugene V. Debs, the party did not gain prominence until 1912, when Debs polled 6% of the popular vote for president.

er earnings and have not been greatly interested in economic and social organization.

Numerous, although small, utopian socialist communities did flourish, however, in the United States, mostly during the early 19th century. Also, a celebrated economist, Henry GEORGE, and writers of repute, such as Edward BELLAMY, advocated socialism, and socialist political leaders, such as Victor L. BERGER, Eugene V. DEBS, Daniel DE LEON, and Norman THOMAS, had at one time considerable popular appeal. The U.S. SOCIALIST PARTY, founded in 1901, reached its greatest strength in the 1912 and 1920 presidential elections, when its candidate, Debs, received more than 900,000 votes. In 1932, Norman Thomas, running on the Socialist ticket, polled more than 800,000 votes. Thereafter the party's strength ebbed. In the 1930s the New Deal's policies of economic redistribution seemed to meet demands of those who previously supported the Socialists.

In the economic boom following World War II and especially in the cold-war era of the 1950s and '60s socialism was at a low ebb. More recently, however, socialist ideas have made considerable, although indirect, impact on various radical (see RADICALISM) and liberal movements.

Socialism in the Third World

Socialism has assumed a number of distinct forms in the Third World. Only in Israel has moderate social democracy proved successful for long periods, mainly as a result of the European socialist tradition brought by immigrants. There the Labor party in various forms has had a large following and governed the country for the longest time since the foundation of the republic. Israel has other socialist parties as well, including a militant Marxist party. At least of equal significance, however, are the cooperative agricultural communes (*kibbutzim*), which have flourished since 1948.

Elsewhere in the Third World, Marxism and various indigenous traditions have been predominant in socialist movements. In developing countries socialism as an ideology generally has been fused with various doctrines of nationalism enriched by diverse motifs drawn from local traditions and cast in the idiom of indigenous cultures. In India, for example, the largest socialist movement has partially adapted the pacifist teaching of Mahatma Gandhi, and distinct native brands of socialism exist in Japan, Burma, and Indonesia. Similarly, in black Africa idigenous traditions have been used in the adaptation of socialist, mainly Marxist, doctrines and political systems based on them. Noteworthy instances are the socialist system of Tanzania and the socialist theories of intellectual leaders such as Kwame NKRUMAH of Ghana, Julius K. NYERERE of Tanzania, Léopold Sédar SENGHOR of Senegal, and Sekou TOURÉ of Guinea. Socialism in these theories is usually understood as a combination of Marxism, anticolonialism, and the updated tradition of communal landownership and tribal customs of decision making. Arab socialism likewise represents an effort to combine modern European socialist ideology with some Islamic principles. The BAATH PARTY in Iraq and Syria and the Destour party in Tunisia have held power for considerable periods; Algeria also has had a socialist system since its independence. In the Third World, however, socialism is often simply an ideology of anticolonialism and modernization. Overtly Marxist movements, aided by the USSR, China, or Cuba, have seized power in such African countries as Angola, Ethiopia, and Mozambique. South Africa's AFRICAN NATIONAL CONGRESS (ANC) is also strongly influenced by Marxist ideas.

The New Left

In the West in the 1960s a radical socialist movement, known as the New Left, arose principally out of the disaffection of young people with the way of life of advanced industrial society, and not least with its prosperity and conformism. The movement, which was apolitical in nature, sought to expose the growing "alienation" of the individual in advanced industrial conditions, castigating the values of the "consumer society" and attacking many prevailing social institutions. The New Left has not so far proved a significant or lasting influence on socialism.

Julius Nyerere, first president of Tanzania, initiated (1967) socialist programs that have emphasized rural development through the creation of communal villages. His goals, detailed in his Freedom and Socialism *(1968), have focused on the traditions and needs of an African agricultural economy.*

It could well be argued that socialism as an alternative system of society and government has failed hitherto to live up to its promises; by and large it is still no more than a dream or at best a set of ideal criteria whereby to judge the shortcomings of existing institutions. Socialist ideology, however, remains a popular and widely held political belief today, and it has deeply penetrated other ideologies, as can be seen, for example, in the acceptance by many conservatives of the WELFARE STATE and planning. The worldwide spread of socialist ideas has also been accompanied by a process of dilution of original principles, as in Western social democracy, and by the degeneration and falsification of its values, as in Marxist states.

Socialist International see INTERNATIONAL, SOCIALIST

Socialist Labor party The Socialist Labor party, an outgrowth of a New York City workers' party (1874), became a national U.S. political party by the end of the decade and took the name Socialist Labor party in 1877. In 1880 it allied itself temporarily with the GREENBACK PARTY; in the 1890s it was led by the Marxist Daniel DE LEON, editor of the weekly *The People*; and in 1892 it ran its first presidential ticket. De Leon's syndicalist tendency, however, was opposed by many members, who, led by Morris Hillquit, split off and helped form the Socialist party. The Socialist Labor party then declined, and its continuing influence has been minimal.

Socialist party During the Progressive Era (early 20th century), the American Socialist party presented the only significant political challenge to U.S. capitalism. Formed in 1901 by Victor L. BERGER, Job Harriman, and Morris Hillquit of the Socialist Labor party and Eugene V. DEBS of the American Railway Union, the party faced two serious handicaps. At the 1894 convention of the American Federation of Labor (AFL), which represented skilled craftworkers, federation leader Samuel GOMPERS had skillfully maneuvered to prevent AFL endorsement of socialism; thus the party never won the skilled-trade-union support that bolstered its European counterparts. In addition, the INDUSTRIAL WORKERS OF THE WORLD (IWW) failed in its goal of building a permanent organization of unskilled migrant workers and immigrants; therefore, the Socialists also lacked a base among nonskilled-industrial-union members. Because of these and other problems, the party collapsed after a decade.

The Socialist party reached its apex in 1910–12 with about 118,000 dues-paying members. One thousand Socialists were elected to state and local public office. In 1910, Berger became the first Socialist elected to Congress; Debs won 6 percent of the presidential vote in 1912. Among the party's hundreds of publications were the *Appeal to Reason, Jewish Daily Forward, Masses*, and *International Socialist Review*.

The party was torn, however, between the reformist, AFL-oriented, center-right of Hillquit and Berger, who controlled the organization, and leftist advocates of revolution, such as William HAYWOOD and Debs. Its decline was furthered by a reformist drift toward the progressive Democrat Woodrow Wilson and by the departure of intellectuals disturbed by the party's pacifism during World War I.

Drastically reduced by government repression and Bolshevik defections, the party joined (1924) the PROGRESSIVE PARTY coalition behind the independent presidential candidacy of Robert La Follette. After 1926, Norman THOMAS unsuccessfully attempted to re-create a leftist coalition. Increasingly fragmented, the Socialists abandoned even presidential campaigns after 1948.

socialist realism Socialist realism has been the Soviet Union's official doctrine on literature since it was first formulated by the Communist party in 1932 and then articulated by Maksim GORKY at the First Congress of the Union of Soviet Writers in 1934. According to this doctrine, all literature must serve the higher purposes of Soviet society by educating the working masses in the principles and practices of socialism; literature must be realistic and comprehensible, not experimental or negative, as it is in bourgeois societies.

Typical of socialist realism is the "positive hero" or "new Soviet man," usually a worker who strives heroically and optimistically for the future perfection of socialism. Examples of such fiction include *The Nineteen* (1927; Eng. trans., 1929) by Aleksandr Aleksandrovich Fadeyev; *How the Steel Was Tempered* (1932–34; Eng. trans., 1937) by Nikolai Alekseyevich Ostrovsky; and *The Virgin Soil Upturned* (1932–33 and 1960; Eng. trans., 1935 and 1960) by Mikhail Aleksandrovich SHOLOKHOV.

Socialist Workers' party The Socialist Workers' party, headquartered in New York City, was founded Dec. 31, 1937, as a successor to the Communist League of America by James P. Cannon and a group of American followers of Leon Trotsky, then living in exile in Mexico. Its goal was to overthrow the capitalist state and found a workers' state governed by the proletariat. From its inception the party has been active within the Fourth Socialist International. The Young Socialist Alliance, its youth wing, was founded in 1957. Since its founding the party has attempted to gain success through the electoral system, participating in local and national elections. From 1945 to about 1963 the FBI conducted electronic surveillance of party members.

socialization *Socialization* is a term used by sociologists and other social scientists for the means by which the members of one generation in a society acquire knowledge, behavior, and ideals from older generations. The process of socialization, which starts in infancy, includes learning acquired from the family, from playmates, and through formal education. It involves learning the informal and formal rules of one's society by imitation, by rewards and discipline, and from conscious indoctrination as well as unconscious approval or disapproval. Socialization ensures the continuation of society. Some anthropologists use the term *enculturation* to refer to the process of socialization.

Society Islands The Society Islands, part of FRENCH POLYNESIA in the south central Pacific Ocean, consist of two island groups—the Leeward Islands and the Windward Islands. They have a total land area of about 1,680 km^2 (650 mi^2) and a population of 162,573 (1988). The main islands are TAHITI and Moorea in the Windwards and Bora-Bora and Raiatea in the Leewards. The capital, Papeete (1988 pop., 23,555), lies on Tahiti. Volcanic in origin, the islands rise to 2,237 m (7,339 ft) in Mount Orohena on Tahiti.

The first Europeans to visit the islands were probably the Portuguese in 1607. The islands were named by James Cook, who visited them in 1769. They came under French control in 1843.

Society for the Prevention of Cruelty to Animals The Society for the Prevention of Cruelty to Animals (SPCA) is the generic term for multiple separate organizations throughout the United States that seek to assure the humane treatment of animals, the maintenance of animal shelters, and enforcement of the laws relating to animal care.

The first such society, the American Society for the Prevention of Cruelty to Animals (ASPCA), was chartered in the state of New York in 1866. In New York, ASPCA agents are empowered to act as officers of the peace. They may carry firearms, sue an owner for mistreatment of an animal, and, with court permission, remove an animal from the possession of its owner. The ASPCA is the principal provider of shelters for abandoned animals. SPCA organizations in other states have modeled their programs on New York's.

Socinianism [soh-sin'-ee-uhn-izm] *Socinianism* is the name given to the specific form of anti-trinitarianism or UNITARIANISM stated by the Italian theologian Socinus (Fausto Paolo Sozzini, 1539–1604) and developed during the early 17th century, particularly in Poland. Socinus grew up in Italy under the influence of his uncle Laelius Socinus. When he raised doubts about the divinity of Christ, he came into conflict with the teachings of both Roman Catholicism and the Reformation.

Socinus prepared drafts for the Racovian Catechism, the first formal statement of Socinian beliefs, which was published at Raków, in southern Poland, in 1605. It set forth a moderate form of unitarianism that stated that Christ was a man who received divine power as a result of his blameless life and miraculous resurrection. The movement was suppressed in Poland after 1658, but Socinian groups survived in Transylvania, England, and elsewhere.

Socinus, Laelius [soh-sy'-nuhs, lee'-lee-uhs] Laelius Socinus, b. Lelio Francesco Maria Sozini, Mar. 25, 1525, d. May 14, 1562, was an Italian theologian whose ideas influenced the later antitrinitarian and unitarian movements. From 1545 he traveled widely in Europe, establishing close contacts with such Reformation leaders as John Calvin, Heinrich Bullinger, and Philipp Melanchthon, often serving as their messenger. Although personable and generally well liked, his uninhibited questioning of such doctrines as the Trinity and the Incarnation ultimately gave rise to suspicions on the part of some of the reformers. He died at the age of 37, shortly after the sequestration of his property by the Inquisition.

sociobiology Sociobiology, or the study of animal and human social behavior in terms of evolutionary biology, holds that the theory of evolution by natural selection applies to behavior in the same way that it applies to structure and physiology. Accordingly, it relies upon the principle that genes are able to influence behavior and will be selected if the behaviors they encourage contribute ultimately to the reproductive success of the individuals carrying those genes. The "fitness" of an organism or a gene is a measure of the ability of that organism or gene to project copies of itself into future generations. Because natural selection would influence genetically controlled behaviors, sociobiologists believe that individuals will tend to behave in ways that maximize their fitness.

In the 1960s, population geneticist W. D. Hamilton developed the concept of kin selection, which emphasized evolution from the gene's point of view. This concept was first applied to understand altruism among animals, a behavior in which social animals such as ants care for young other than their own. At about the same time, biologists were also becoming increasingly aware of the role of selection acting upon individuals, rather than upon species or groups, in generating adaptive traits. This information, along with that resulting from extensive studies of wild animals, behavioral genetics, and evolutionary ecology, provided theoretical bases for the development of sociobiology. Models of evolution also were applied to behavior such as territorial defense, mate selection, reciprocal altruism, parental investment, and parent-offspring conflict. Harvard zoologist Edward O. Wilson combined a massive amount of theory and data in his *Sociobiology: The New Synthesis* (1975), which defined the field.

Sociobiology has provided a valuable perspective on animal social behavior, especially regarding altruism, reproductive systems, and patterns of communication and social organization. Researchers have confirmed that, with few exceptions, living things behave in ways that maximize their fitness with regard to aggressiveness, male-female differences, dominance hierarchies, mate selection, care of offspring, territoriality, and predator avoidance. Sociobiology remains controversial in the area of human behavior, however, although it has won many converts, especially among anthropologists, psychologists, and psychiatrists.

sociolinguistics Sociolinguistics is the study of all facets of the relation between language and social organization. Although it is a relatively new science—it developed during the early 1960s as an interdisciplinary field combining aspects of ANTHROPOLOGY, LINGUISTICS, social and educational PSYCHOLOGY, and sociology—sociolinguistics has already developed three prominent subdisciplines: sociolinguistic variation, involving the evolution and description of languages; the ethnography of speaking, which examines the social conventions governing linguistic interaction; and the sociology of language, which focuses on how a society's structure affects its choice of a language.

Sociolinguistic Variation

Late-19th-century dialectologists had already formulated the key concept of sociolinguistic variation—that speakers have available to them different ways of saying the same thing—and went on to note such explanatory factors as geographical area (see GEOGRAPHICAL LINGUISTICS), socioeconomic class, and age. During the first half of the 20th century attention centered on developing new techniques for describing languages. In 1954, Uriel Weinreich called for greater mutual influence between dialectology and descriptive studies. Nine years later William Labov demonstrated in a paper on the spread of two sound changes on Martha's Vineyard that linguistic change could actually be observed in progress.

Methods of Data Collection. In subsequent studies of English in New York City, Labov and his coworkers built on and revised the methods of data collection of American dialectology. They adapted from sociology more precise methods for measuring social categories as well as the survey techniques of random sampling to ensure that a relatively small population fairly represents a much larger one. Whereas European dialectologists had used only rural and so-called lower-class speakers in their samples, as early as 1933 the American dialectologist Hans Kurath distinguished between lower- and middle-class speakers. Labov's subsequent use of more precise sociological categories succeeded in providing a more detailed view of the social basis of linguistic variation.

Bilingualism, Pidgins, and Creoles. In 1967, Roger Shuy and Walt Wolfram adapted Labov's methods to investigate social correlates, including class, age, sex, and race, of linguistic variation in Detroit. The next year Joshua Fishman and his associates applied sociolinguistic methodology to their study of Spanish and English in a bilingual Puerto Rican community in Jersey City, N.J.

During the 1970s sociolinguists turned their attention to pidgin and creole languages. Using the methodology devised for analyzing variation in speech, Gillian Sankoff studied (1971) the process of creolization of Tok Pisin, a New Guinea pidgin; Derek Bickerton did the same (1977) for the Hawaiian English spoken by first- and second-generation Japanese and Filipino immigrants.

Variation within Languages. In 1958 sociologist Charles Ferguson, citing French and Haitian creole in Haiti and vernacular and standard Arabic, described a situation in which two varieties of the same language were known throughout the community but used on different occasions. During the same year anthropologist John Fischer examined the distribution in English of the *-in'* and *-ing* variants of such words as *talking* and *nothing*. Although most speakers classified *-ing* as the standard form and *-in'* as a colloquial variant, Fischer found that everyone used both forms on all occasions, with only the proportions changing in different situations. Labov, beginning in the early 1960s, discussed such irreducible variation and developed the concept of the sociolinguistic variable—a linguistic unit always presenting more than one variant but sensitive to social and linguistic context.

Rules of Variation. Influenced by the rule-writing conventions being developed during the 1960s by Noam CHOMSKY, Morris Halle, and others to explicate phonology and syntax, Labov and his coworkers devised a model for rules of linguistic variation of the type exemplified by the nonarbitrary deletion of final *t* from English consonant clusters. In the early 1970s, David Sankoff and Henrietta Cedergren designed a computer program, VARBRUL, to test correlations between linguistic and social variants. Sociologists committed to developing such models or programs are sometimes called variationists. Others see only a limited linguistic application for variable-rule analysis.

The Ethnography of Speaking

A second subdiscipline of sociolinguistics, the ethnography of speaking, so-named by Dell Hymes in 1962, deals with aspects of language traditionally of more concern to anthropologists than to linguists. Another term of Hymes's, *communicative competence*, points up the need for linguists to go beyond Chomsky's goal of understanding an individual's ability to create and apprehend sentences and to analyze such extra-sentence-processing abilities as knowing when to speak and when not to speak, knowing the kind of speech appropriate to different occasions, and knowing how to construct and recognize discourses connecting many sentences. ETHNOGRAPHY—the description and classification of cultures—comes to the fore when sociolinguists examine linguistic interaction between small groups or individuals representing different cultures.

The Sociology of Language

The sociology of language explores the social correlates of multilingualism. Joshua Fishman, pursuing questions that crystalized during the early 1960s, has analyzed the conditions that have led some populations to abandon one language in favor of another, while other populations have remained multilingual. The subdiscipline remains distinct from that of sociolinguistic variation in that it always works at the macrolevel (involving large groups or societies) and studies the effect of social structure on language choice rather than on linguistic structure.

sociology Sociology is often described as the study of human social relations or group life or as the science of

Auguste Comte, considered a founder of sociology, believed that the scientific study of social organization would make possible a reconstitution of the social order based on principles of moral progress.

society. The field of sociology, unlike other disciplines within the social sciences, lays claim to the whole of human life beyond the biological level because virtually all human activities possess a social aspect.

The Sociological Perspective

In analyzing and theorizing about the social aspects of human activity, sociologists have developed a number of important concepts. The most comprehensive of these are the sociological definitions of society and CULTURE. Sociologists use the term *society* to refer to all the social relations and groups formed by human beings; *a society*, as a singular unit, refers to members of a particular population occupying a particular territory. The term *culture* refers to all the ways of thinking, feeling, and acting that people learn from others as members of society (not just to the higher aesthetic activities).

Major Concepts. Social interaction, or the mutual responses of two or more individuals, is perhaps the most basic sociological concept, for such interaction is the elementary component of all the relationships and groups constituting human society. Sociologists who concentrate on the details of particular interactions as they manifest themselves in everyday life are sometimes called microsociologists; those concerned with the broader pattern of relations among large organizations, such as those composing the state and the economy, and even among entire societies, are called macrosociologists. Thus some sociologists study how people avoid bumping into each other on the street or how they open and close telephone conversations, whereas other sociologists study world systems, or the entire range of economic, political, and other interdependencies among all peoples on Earth. Most sociologists, however, study social phenomena falling somewhere between these two extremes.

Human interaction both creates and is governed by social NORMS—rules or imagined models of conduct present in people's consciousness that guide and control their interactions. Social norms are the part of culture learned by members of a society that is of special concern to sociologists. The laws enforced by the state are one kind of social norm; FOLKWAYS, etiquette, rituals, and fashion are also social norms, although not embodied in legal statutes. Not all norms apply to every member of society, for individuals differ in the parts they play in interaction with others. When these different parts become expectations to which people feel an obligation to conform, they are called social ROLES—clusters of norms and expectations that apply to different classes of persons. Examples of social roles in various societies include those of son, wife, priest, beggar, aristocrat, salesclerk, old man, and warrior.

A social group is a plurality of individuals in recurring interaction, their interactions controlled by common norms and differentiated roles. The members of a group are at least partially aware of their membership and perceive the group as a coherent, fairly permanent entity. Groups may vary in size from two or three friends who lunch together to thousands of people, not all of whom are personally acquainted. Any recurring pattern of interaction among individuals playing different roles may be said to possess or to constitute a social structure (see SOCIAL STRUCTURE AND ORGANIZATION). One may therefore speak of the social structure of the American middle-class family, of a nonliterate tribe, of General Motors or Harvard University, of a juvenile gang, or even of American society as a whole. The study of such structures of interlinked roles and groups differentiates sociology proper from SOCIAL PSYCHOLOGY, the study of the impact of norms, roles, and groups on the individual personality.

Sociological concepts range from universal concepts applicable to all societies, such as those just described, to more historically specific concepts, relevant only to some societies in particular times and places, such as the CITY, BUREAUCRACY, or SOCIAL CLASS.

Subfields. Many of the major subfields of sociology involve the naming of a recognized area of human activity preceded by the phrase "the sociology of." Established fields of teaching and research include sociologies of politics, law, religion, education, industry, art, language (SOCIOLINGUISTICS), science, medicine, and the city (urban sociology).

The French sociologist Émile Durkheim demonstrated a correlation between cultural values and the quality of individual lives. In his seminal work Suicide *(1897), Durkheim identified materialism and mechanization as threats to social and personal stability.*

The German social theorist Max Weber made important contributions to political sociology and to the sociology of religion. Weber investigated the relationship between belief systems and economic development in his influential book The Protestant Ethic and the Spirit of Capitalism *(1904–05).*

Sociologists also study social phenomena that are not the subjects of any other scholarly discipline; these include MARRIAGE and the FAMILY; CRIME and DEVIANCE; social inequality and stratification; ethnic and racial relations; POPULATION growth and its determinants; social gerontology; and the sociology of sex, or gender, differences. Criminology and DEMOGRAPHY have both become virtually autonomous specialties within sociology, especially in the United States. Criminology has been penetrated by more general sociological concerns and has tended to become part of the broader study of all kinds of deviant behavior, including those behaviors not involving violations of the law. In demography the study of fertility and of migration has been greatly influenced by sociological ideas, but the analysis of mortality and the application of mathematical models to population growth and change are more closely tied to other disciplines.

Sociologists are active in some subfields that are fully interdisciplinary. The oldest and most important of these is social psychology. Sociological social psychologists have pioneered in the study of interaction in small informal groups (group dynamics); the distribution of beliefs and attitudes in a population, often called public opinion; and how individual personality is shaped through the experience of SOCIALIZATION, or the formation of character and outlook under the influence of the family, the school, the peer group, and other socializing agencies. Psychoanalytic ideas derived from Sigmund Freud and his followers have been particularly influential in this last field.

A newer interdisciplinary subfield is SOCIOBIOLOGY, which investigates the causal relations between the human genetic constitution and social behavior. Named by the Harvard University entomologist Edward O. Wilson (1929–), sociobiology has attracted a small but vigorous number of sociologists, although it has been assailed by others as a revival of post-Darwinian biological determinism.

Methods. Sociologists make use of nearly all the methods used in the other social sciences and the humanities, from advanced mathematical statistics to the interpretation of texts. Quantitative methods, increasingly refined and adapted to computer technology, continue to play a central role in the discipline, predominating in the research reported in sociology journals. Quantitative research draws data from a variety of sources: official statistics, such as those contained in censuses and in reports on crime or unemployment made by government agencies; opinion and attitude surveys based on questionnaires submitted to large samples of people; and computer simulations of social processes.

Qualitative methods range from ethnographic fieldwork to documentary historical research. Such methods, especially direct social observation at the level of everyday life and the interpretative (or hermeneutical) understanding of the meaning of human productions, have been preferred by sociological followers of various newly influential philosophies of human action, including phenomenology, existentialism, neo-Hegelian Marxism, post-Wittgensteinian linguistic analysis, and structuralism. These approaches have given priority to the methods of everyday experience and of ordinary language over the quantitative measurement of human conduct and the elaboration of highly abstract conceptual schemes.

History of Sociology

Origins in Europe. The concept of "civil society" as a realm distinct from the state—as expressed in the writings of Thomas Hobbes, John Locke, and later political thinkers of the Enlightenment—anticipated the subsequent focus of sociology, as did the philosophies of history of the Italian Giambattista Vico and the German G. W. F. Hegel with regard to the study of social change. The first definition of sociology was put forth by the French philosopher Auguste COMTE, who in 1838 coined the term *sociology* to describe his vision of a new science that would discover laws of human society resembling the laws of nature by applying the methods of strictly factual investigation that had proved so successful in the physical sciences. The philosopher Herbert SPENCER in England soon took up both Comte's term and his mission.

Several near-contemporaries of Comte and Spencer are today also counted as founding fathers of the discipline. Karl MARX is the most important among them, but their number also includes Claude Henri de SAINT-SIMON, Alexis de TOCQUEVILLE, and to some extent John Stuart MILL. These men were largely speculative thinkers, although a quite different tradition of empirical, chiefly quantitative reporting of social facts also developed in the 19th century. This empirical tradition later became incorporated into academic sociology.

Not until the 1880s and '90s did sociology begin to be recognized as an academic subject. In France, Émile DURKHEIM, the intellectual heir of Comte, taught sociology at the universities of Bordeaux and Paris and founded the first real school of sociological thought. In Germany, by the first decade of the 20th century sociology was recognized as an academic discipline, largely because of the efforts of Max WEBER. German sociology, in contrast to the empirical tradition dominant in France and the English-speaking countries, was largely an outgrowth of far-ranging historical scholarship; of a dialogue with Marxism; and of the human-centered focus of German philosophical idealism. The first two emphases were central to Weber's work, and the last predominated in the efforts of Georg SIMMEL to define sociology as a distinctive discipline.

Emergence in the United States. It was in North America that sociology embedded its deepest roots, originally under the influence of Herbert Spencer's efforts to apply the Darwinian idea of evolution to human society. One of the key American Spencerians was William Graham SUMNER, who is believed to have taught the first course in sociology at Yale University as early as 1875. The first department of sociology was established (1893) at the University of Chicago, and following the emergence of a coherent Chicago school after World War I, that city remained the center of American sociology until the 1940s.

Sociology during the first half of the 20th century became primarily an American subject. After the decline of broad evolutionist theories in the Comtean and Spencerian mode, American sociology grew heavily empirical, quantitative, and oriented to the study of particular social problems, such as crime, marital discord, and the acculturation of immigrants. An exception was the influence at Chicago of George Herbert MEAD, a pragmatist philosopher who had studied in Germany and whose stress on the roots of mind, self, and society in linguistic communication gave rise to an approach named *symbolic interactionism* by the sociologist Herbert Blumer (1900–87).

In the 1930s, Talcott PARSONS of Harvard University introduced the ideas of the European sociologists Durkheim, Weber, and Vilfredo PARETO in a major work (*The Structure of Social Action*, 1937) that single-handedly overcame the parochialism of American sociology. Leadership in sociology under the stewardship of such theorists as Parsons and Russian-born Pitirim A. SOROKIN for a time passed to Harvard and on to Columbia University. There a student of Parsons's, Robert MERTON, attempted to unite theory with empirical research. He was aided in this effort by the quantitatively skilled Austrian-born sociologist Paul F. Lazarsfeld (1901–76). Another Columbia sociologist, C. Wright MILLS, brought the ideas of Weber and European Marxism to bear on his overall historical analysis of American society. At Harvard, Parsons constructed an elaborate theoretical system that attempted to account for virtually everything in human society. In the 1960s he was assailed by Mills and others, including a new generation of academic Marxists, for his allegedly conservative bias reflected in his relative neglect of group conflict, social change, and the role of power in society.

Later Developments. In the 1970s the currents of theoretical influence began once again to flow from Europe. Jürgen Habermas, the heir of Germany's Frankfurt school of neo-Marxism, emerged as a master synthesizer. French neo-Marxist structuralism also became an influence. In addition, a number of highly sophisticated younger British sociologists combined British analytic philosophy with the themes of both European and American microsociology and macrosociology. New versions of symbolic interactionism, systems theory (formerly called structural-functionalism), and phenomenology also flourished on both sides of the Atlantic. At the level of theory as well as of method and subject matter, sociology has become a house of many mansions, in which no single school of thought, nation, university, or topic holds clear ascendancy.

Socotra [suh-koh'-truh] Socotra, which became a part of Yemen in 1967, is a 3,580-km^2 (1,382-mi^2) island in the Indian Ocean, south of Arabia, at the mouth of the Gulf of Aden. The capital and largest town is Tamrida. Except for narrow coastal plains, Socotra is occupied by the Haggier Mountains. Economic activities include tobacco and date cultivation, the extraction of myrrh and frankincense, fishing, pearl diving, and livestock raising. Known since biblical times, Socotra was held by the Portuguese (1507–11). The inhabitants converted from Christianity to Islam during the 16th and 17th centuries. Socotra became part of Britain's Aden Protectorate in 1886.

Socrates [sahk'-ruh-teez] Socrates, *c.*469–399 BC, was an ancient Greek thinker whose work marked a decisive turning point in the history of Western philosophy. He invented a method of teaching by asking questions (the Socratic method), pioneered the search for definitions, and turned philosophy away from a study of the way things are (the orientation of PRE-SOCRATIC PHILOSOPHY) toward a consideration of virtue and the health of the human soul. Although he wrote nothing himself, Socrates exerted an enormous influence through the work of his student PLATO.

Life. What is known about Socrates' life can be stated briefly. He was born in Athens and lived all his life there, leaving only to serve as a soldier in the Peloponnesian War. He was married to a woman named Xanthippe and had two sons at the time of his death. Ugly and eccentric, he apparently supported himself as a stone carver but attracted a number of prominent disciples in his role as a teacher of wisdom. In 399 BC, at about the age of 70, he was accused of impiety and of corrupting the youth of the city by questioning tradition. Convicted and sentenced to death, he died by drinking poison. Socrates' death scene, described in Plato's *Phaedo*, is one of the most famous in literature.

Further details of his life and teaching are recorded in Plato's dialogues (chiefly the *Apology* and *Crito*), in the *Memorabilia* and other works of Xenophon, and in Aristophanes' play *The Clouds*. The historical accuracy of these sources is questionable, but Plato's Socrates, even though he is made to express ideas that were probably Plato's, is considered closest to the truth. Aristophanes identified Socrates with the SOPHISTS, whose relativism appeared to undermine traditional morality, and this may be how he was perceived by most Athenians. Plato tried to counter this image by showing Socrates attacking and defeating the Sophists in argument. Socrates would challenge anyone with a pretense to knowledge, however, and this might have angered the Athenian leaders more than anything else.

Philosophy. Socrates hides behind a mask of irony in Plato's dialogues. He asks many questions, gives few answers, and denies that he knows the matters under dis-

Socrates, the great philosopher of classical Athens, reportedly spent his life in conversation with Athenian citizens, seeking true knowledge and exposing the errors of those who claimed to have wisdom. His persistent questioning so antagonized the city fathers that he was accused of heresy and of corrupting youth; Socrates was sentenced to death by poisoning in 399 BC.

cussion. Nevertheless, he preaches certain ethical doctrines explicitly and is implicitly committed to the principles that guide his method.

Socrates believed that to do wrong is to damage one's soul, and that this is the worst thing one can do. From this it follows that it is always worse to do wrong than to be wronged and that one must never return wrong for wrong. Socrates also maintained that virtue is knowledge (the Socratic paradox), and thus that no one can do wrong in full knowledge. Hence Socrates believed that no one errs voluntarily. From this also comes Socrates' doctrine of the unity of the virtues: all the virtues really amount to the same thing, to knowledge. Socrates lived and died by his principles. After his trial his friends arranged for him to escape, but rather than do wrong to the city by flouting its laws he remained in prison and suffered the death penalty.

Socrates assumes that if one knows something one will be able to define it; anybody who is an expert on virtue, for example, will be able to say precisely what virtue is. Thus Plato shows him continually asking for definitions. Moreover, Socrates always insists on being given a definition that universally covers its subject. This was of the greatest importance for the subsequent development of philosophy because it led to the concept of a UNIVERSAL (a general quality that may be present in many individually existing things). Also important is Socrates' implicit assumption that any person to whom he talks has within him or her the resources to answer questions correctly. Socrates therefore believes that he can teach merely by asking the right questions.

soda Soda is the collective name for several forms of sodium carbonate (see SODIUM). The most commercially important form is the dehydrated product soda ash (Na_2CO_3). The decahydrate ($Na_2CO_3 \cdot 10H_2O$) is also known as washing soda or sal soda. Soda ash is so called because it was once extracted from plant ashes; now almost all is manufactured by the Solvay or ammonia-soda process. The primary users of soda are the glass and chemical industries. Sodium carbonate occurs in nature in combination with the bicarbonate as trona and is recovered from evaporated lakes in California. Baking soda (sodium bicarbonate, $NaHCO_3$) is used as an effervescent agent in foods and as a cleanser.

sodium The chemical element sodium is a soft, silver-colored metal, waxlike at room temperature but becoming brittle as the temperature falls. Its symbol is Na, its atomic weight is 22.9898, and its atomic number is 11. Sodium is a member of the ALKALI METALS—Group 1A of the PERIODIC TABLE—a family that includes the elements lithium, potassium, rubidium, cesium, and francium.

History

Compounds of sodium were known and used extensively during ancient times, but the highly reactive nature of the element prevented its preparation as a pure substance until 1807. Until recently, the Natròn valley near Cairo, Egypt, because it is below sea level, annually formed lakes upon inundation by the floodwaters of the Nile. These lakes became nearly dry during summer, leaving a deposit of a white, saltlike substance that came to be called natron. For thousands of years it has been used for embalming, in ceramic pastes, as a detergent, and, when mixed with sand, in the production of glass. We now know that natron, or natrum, is principally sodium carbonate containing smaller quantities of sodium bicarbonate, sodium sulfate, and sodium chloride.

As chemistry evolved from alchemy, natron, niter, and soda (sodium carbonate) were recognized as identities, although it was many years before potassium carbonate was differentiated from the sodium salt.

In 1807, Humphry Davy, director of the laboratory of the Royal Institution and one of the earliest electrochemists, electrolytically produced a heretofore unknown element from molten potash (potassium carbonate). Because of its source, he called it POTASSIUM. Within days, Davy repeated the experiment using molten soda (sodium carbonate), and after increasing the voltage of his electrical source, produced another elemental metal, which he named sodium.

Occurrence

Because of its extreme reactivity, sodium is not found free in nature, nor can it be used in its elemental state except in the absence of oxygen. The seventh most prevalent element, sodium composes 2.83% of the Earth's crust, and the annual world consumption of sodium and sodium compounds is more than 100 million metric tons. The seas are large reservoirs of sodium as common salt, sodium chloride (NaCl); tremendous subterranean deposits of salt are common throughout the world, as exemplified by the still-worked beds discovered in Poland in 1251 and by similar beds in Kansas, Oklahoma, Texas, Louisiana, Ohio, Michigan, and New York. Sodium is present in basalt, lava, feldspar, and as sodium silicate in the various sands and silicate rocks of the Earth. Although the element is not essential to plant life, it is normally found in plants, principally as sodium chloride. Sodium is essential to all animal life.

Properties

Sodium is a soft metal, easily cut with a knife or pressed into wire. Its melting point is 97.81° C, and it boils at 882.9° C. Its density is 0.97, slightly less than that of water. Sodium has only one stable isotope, mass number 23.

Sodium reacts readily with many elements and compounds by acting as a reducing agent; that is, it reacts by giving up (losing) an electron. The tendency to do so is so strong that sodium can replace hydrogen from water: $2Na + 2H_2O \rightarrow 2NaOH + H_2$. The reaction is very vigorous, often generating enough heat to ignite the hydrogen gas and cause an explosion. Sodium forms compounds in which its valence is 1.

Production

Elemental sodium is prepared by the electrolysis of molten sodium chloride, whether laboratory or commercial quantities are desired. Large quantities are readily produced using the Downs cell (see CHLORINE). The sale of the chlorine by-product produced by this method helps reduce the cost of the sodium.

Uses

Both its high reactivity and its cost prevent the use of large quantities of elemental sodium. Significant quantities are, however, used in the production of sodium vapor lamps for inexpensive highway lighting and in such metallurgical processes as removing antimony from lead and oxygen from silver. Sodium amalgams (solutions in mercury) of various sodium concentrations are useful and manageable reducing agents, even in contact with water.

Sodium Hydroxide. In contrast to the free element, compounds of sodium have industrial uses that require millions of tons annually. Perhaps the most important of these compounds is sodium chloride (NaCl), from which millions of metric tons of sodium hydroxide (NaOH) are made annually. Sodium hydroxide, also called caustic soda, is essential to the production of soap, detergents, cleaning compounds, dyes, cosmetics, and pharmaceuticals. It is also necessary in the manufacture of rayon, cellophane, phenol, naphthol, resorcinol, and oxalic acid. Such industrial processes as boiler-water softening, food processing, engraving, printing, pulp and paper production, petroleum refining, metallurgy, and household-bleach preparation all depend on it.

Sodium Carbonate. Though widely used in the chemical industry, sodium carbonate (Na_2CO_3), soda ash, is principally consumed by the glass industry, in which about 7 million metric tons are needed annually. Large quantities are used as well in sewage treatment and in water softening for municipalities and industry. Sodium carbonate is also used in the production of the sodium acetate used in textile dyeing and leather tanning and for making sodium arsenate for use as a pesticide. Natural sodium carbonate is obtained in the United States principally from brines of the dry lakes in southern California and from deep deposits in Wyoming.

Other important compounds manufactured from sodium carbonate are sodium bisulfite, sodium sulfite, sodium perborate, sodium linoleate, and sodium thiosulfate.

Sodium sulfite and bisulfite are used in photographic products and in the pulp-and-paper and textile industries. Sodium perborate is used in dentifrices, deodorants, and cold-wave neutralizers. Sodium linoleate is used as a drier in paints. Sodium thiosulfate is an antioxidant used in cosmetics and an image fixer in photography.

Sodium Silicate. Although often written as Na_2SiO_3, sodium silicate is a complex mixture of Na_2O and SiO_2. It is commercially called water glass and is produced by fusing high-purity sand (SiO_2) and sodium carbonate.

Variation in the Na_2O/SiO_2 ratio produces properties that allow its use as builders in soaps and detergents, as lubricants in petroleum recovery, as catalysts, as desiccants, and as adhesives. Large quantities of sodium silicate adhesives are used in making fiberboard boxes, because the quick setting permits low-cost, continuous, high-speed manufacture of corrugated boxes.

In the form of silica gel, sodium silicate has a high surface area and therefore a great capacity for moisture absorption. It is used in catalytic processes, as a drying agent, as fillers, and as pigments. When very finely ground it can be used as a pigment in the production of colored rubbers. It is an effective coagulant in removing suspended solids from water and wastewater, and it is also used as a corrosion inhibitor.

The construction industry uses sodium silicates to stabilize soils and to seal against moisture seepage. It fireproofs flammable insulations and makes concrete acid-resistant. Surface coating with sodium silicate waterproofs concrete, increases its hardness, and increases its stain resistance. Metal producers use these silicates as deflocculants in ore floation and in the production of cores and molds.

Other Sodium Compounds. Because most sodium salts are water-soluble, the element is found in a wide variety of compounds in which water solubility is a desirable property. Sodium hypochlorite (NaOCl), sodium chlorite ($NaClO_2$), and sodium chlorate ($NaClO_3$) are notable for their bleaching and sanitation uses (see CHLORINE).

The first of the modern synthetic detergents, Tide, was introduced in 1947 by Procter and Gamble. This combination of a syndet (synthetic detergent), sodium alkylbenzene, with sodium tripolyphosphate leaves no residue and improves cleaning action.

In the form of a naturally occurring sodium mineral known as cryolite, sodium aluminum fluoride is used in tremendous quantities in the production of aluminum metal. The demand is so great that more than 90 million kg (200 million lb) of synthetic sodium aluminum fluoride are produced each year to augment the natural supply.

sodium pentothal Sodium pentothal is an extremely fast-acting barbiturate whose generic name is thiopental sodium. It is a central-nervous-system depressant that, when injected into the bloodstream, rapidly produces deep sleep from which arousal also occurs rapidly. Sodium pentothal is used most commonly to put patients to sleep for surgical operations or dental work. It has also been used, however, to produce a kind of chemical trance during which suppressed memories may be recalled or psychotherapeutic suggestions reinforced—hence its popular, inaccurate name, "truth serum."

sodium pump see ACTIVE TRANSPORT

Sodom and Gomorrah According to Genesis 19, Sodom and Gomorrah were two "cities of the Plain" that God destroyed with a rain of "brimstone and fire" as punishment for their evil ways. Before the destruction God warned LOT to leave Sodom and not to look back; Lot's wife, who looked back on the burning city, was turned into a pillar of salt. The cities were probably located at the southern end of the Dead Sea and devastated by an earthquake *c.*1900 BC.

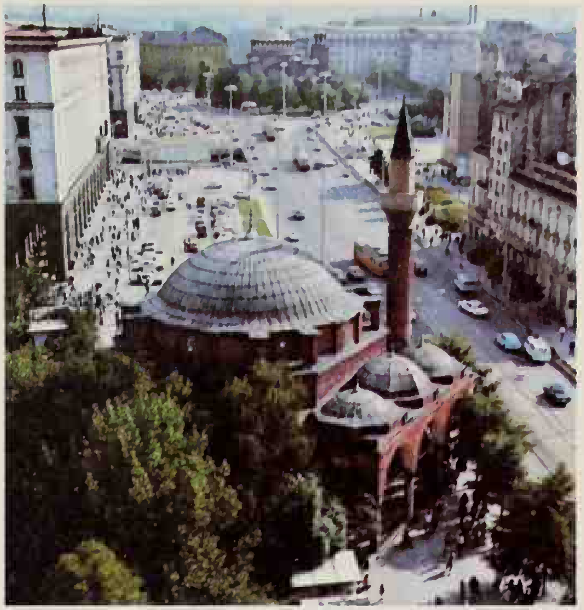
sodomy Sodomy has been defined as carnal copulation against the order of nature and is considered a crime at common law. The name is derived from the ancient biblical town of Sodom, destroyed by heavenly fire for its wickedness. Acts of sodomy include "unnatural," or "deviant" (noncoital, usually referring to anal), sexual intercourse between persons of the same sex or of different sexes. Sodomy was made a felony in England during the early 16th century and has continued to carry often severe penalties under Anglo-American codes.

Objections have been raised in recent years to statutes that punish "deviant" sexual activity between consenting adults in private. It is argued that persons should not be interfered with so long as their activities are not injurious to the public welfare or seriously harmful to others. This argument relies on the "right of privacy" decisions of the U.S. Supreme Court. In the 1986 case of *Bowers* v. *Harwick*, however, the Court held that states do not violate constitutionally protected privacy rights by outlawing sodomy practiced in private by consenting adults.

Sofala see BEIRA

Sofia [soh-fee'-uh] Sofia is the capital and largest city of Bulgaria, with a population of 1,217,024 (1989 est.). It is the political, cultural, industrial, and commercial center of the nation.

Sofia's most important industries produce metal goods, heavy machinery, textiles, processed foods, rubber, leather goods, paper products, and chemicals. The city is also the major market center for Bulgaria's agricultural products and a transportation hub. The University of Sofia (1888), the National Art Gallery, the Cyril and Methodius National Library, the National Theater, and the Palace of Culture are there. Among Sofia's notable buildings are the Alexander Nevsky Cathedral (consecrated 1924), the churches of Saint George (4th century) and Saint Sofia (6th century), a 16th-century mosque, and the mausoleum of Georgi M. Dimitrov, the founder of the People's Republic of Bulgaria.



Two famous structures symbolize Sofia's diverse cultural heritage—the Buyuk Dzhamiya (foreground), *a 16th-century Turkish mosque, and Alexander Nevsky Cathedral* (center, background), *dedicated to Russian troops killed in the war of Bulgarian liberation (1876–78).*

Sofia was founded in AD 29 on the site of an 8th-century BC Thracian settlement by the Romans, who named it Ulpia Serdica. The city was destroyed by Attila the Hun in 447 but was rebuilt in the 6th century by the Byzantines, who renamed it Triaditsa. It was the capital of the first and second Bulgarian empires (809–1018, 1186–1396), acquiring the name Sofia in the 14th century; after 1396 it was ruled by Turks. In 1879, Sofia became the capital of independent Bulgaria.

soft-coated Wheaten terrier The soft-coated Wheaten terrier has long been used as a drover, a home and stable guard, and a vermin dog in its native Ireland, but it has received official recognition only recently. The Irish Kennel Club recognized the breed in 1937, the English Kennel Club in 1943, and the American Kennel Club in 1973. A male Wheaten terrier stands 46 to 48 cm (18 to 19 in) at the shoulder and weighs 16 to 20 kg (35 to 45 lb). Wheaten terriers have small, drop ears and short, docked tails. The wheaten-colored, medium-length coat is profuse and soft, covering the entire animal in large, wavy locks.

softball Softball is a sport similar to BASEBALL, played in the localities where baseball is also popular. The game is played with a larger ball, on a smaller field, and with the same basic equipment as that used in baseball. About 40 million adults and children played some form of competitive or recreational softball in the United States in the early 1990s, making it one of the largest team sports in the country. Softball is a popular alternative to baseball for women at both the high school and college levels.

Joan Joyce, who is credited with pitching more than 130 no-hitters, earned fame while leading Connecticut and California teams to amateur championships. Eddie Feigner traveled widely with a four-man team known as "The King and His Court," combining softball skills with slapstick comedy. Feigner is reported to have pitched more than 750 no-hit games and 200 perfect games (no runs, no hits, no walks).

Fast pitch and slow pitch are the two styles of softball. Softball games customarily last seven innings. The ball is pitched underhand in all versions. Fast pitch is played with teams of 9 players, slow pitch with 10 players per side. Approximately 90 percent of the registered amateur teams in the United States play the slow-pitch game. The ball is pitched slowly in a high arc, making it an easy target for hitters.

In fast-pitch softball, bases are 60 ft (18.3 m) apart, and the pitcher's mound is 46 ft (14 m) from home plate, although the women's mound is closer. A standard ball, with a circumference of 12-in (30.5-cm), is used; bats are generally lighter and shorter than those used in regular baseball.

Slow-pitch softball is played on a field of the same size, but the pitcher is required to lob the ball in such a way that its flight has a 6- to 12-ft (1.83- to 3.66-m) arc, with the ball crossing the plate on its downward flight. Slow-pitch teams use either the standard 12-in ball or occasionally larger ones up to 16 in (40.6 cm) in circumference. Neither bunting nor base stealing is allowed. The 10th player is used either as a short fielder, roving the area between the infield and outfield, or as a fourth outfielder. Hollow metal-alloy bats are widely used in slow-pitch.

A young girl has just hit the ball during a softball game. Because it requires less equipment and offers less potential for injury than does conventional baseball, softball is widely accepted as an athletic activity for school-age children.

Softball originated in Chicago in 1887 as a form of indoor baseball, played with a 16-in ball. The forerunner of the present-day game was developed in Minneapolis, Minn., by Lewis Rober. Each region had its own rules until a rules committee standardized (1923) the game.

The Amateur Softball Association, founded in 1933, is the softball governing body in the United States, with more than 230,000 registered teams, in both fast- and slow-pitch leagues, in 1990. The United States Slo-Pitch Softball Association (USSSA), founded in 1969, had about 60,000 registered teams in 1990.

software, computer see COMPUTER SOFTWARE

soil The term *soil* generally refers to the loose surface of the Earth, as distinguished from solid rock. To the farmer or agronomist, soil is the natural medium for growth of all land plants; civil engineers consider soil an easily disaggregated earth material that supports most foundations, roads, runways, and other constructed works and from which earth dams, embankments, and other earth structures are built.

Soils and Farming

The term *soil* as used in agricultural contexts can be more specifically defined as a thin layer of loose earth materials composed of weathered minerals and decaying organic matter. It provides physical support and nutrients as well as sufficient quantities of air and water for plant growth. Specialists who study and manage soils as a medium for plant growth are called agronomists, or soil scientists.

Soil Profile. All mature soils are made up of a sequence of distinct layers, called horizons, that roughly parallel the Earth's surface. These horizons commonly range from a few centimeters to a few meters in thickness, and each horizon in the sequence differs markedly from the other horizons in chemical, physical, and biological properties. A section cut downward from the surface through the various soil horizons forms the soil profile. From the surface downward, the major soil horizons are designated A, B, and C, respectively. In some cases these layers are further divided into subhorizons designated A1, A2, B1, and so forth. The A horizon (topsoil) is characterized by high biotic activity and an accumulation of organic matter. Water percolating through the A horizon commonly carries fine-grained materials (principally clay particles and colloidal organic matter) downward and deposits them in a zone of accumulation called the B horizon. Thus a principal distinguishing characteristic of the B horizon is a high clay content. The A and B horizons together make up the solum, or true soil. The C horizon is composed of weathered rock underlying the B horizon.

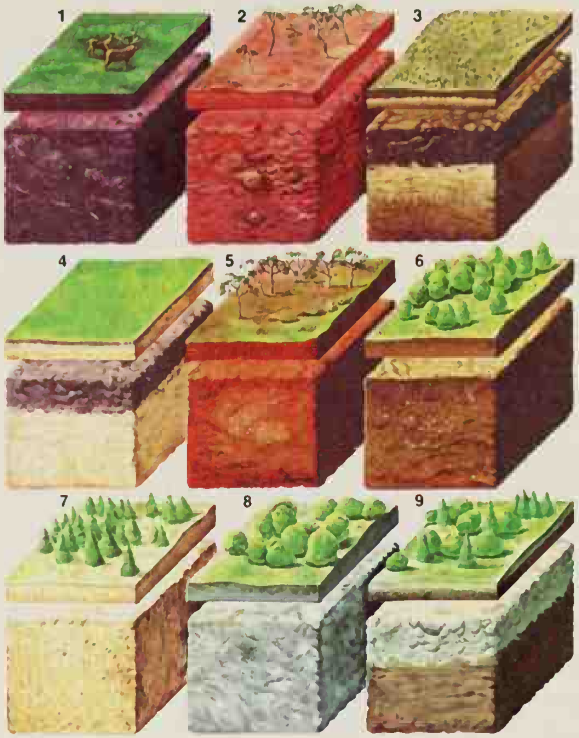
The soil profile is dynamic. Four states of profile development are commonly recognized in the life cycle of a soil: parent material, immature soil, mature soil, and old-age soil. Soils begin their development with parent materials—loose earth materials laid down by wind, water, or glacial ice, or materials weathered in place from rocks. Exposure of the parent material to the weather in most climates results in the establishment of plants. The plants die and leave organic residues on which animals, bacteria, and fungi feed, breaking the residues down to more elementary chemical forms. The breakdown sets nutrients free, making the parent material more fertile for another cycle of plant growth. As more and more organic matter is worked into the parent material, the upper layer assumes a darker color, and an A horizon develops. Such a soil has only A and C horizons and is in the immature stage, which is commonly reached in less than 100 years.

Continued weathering, which is usually accelerated by the actions of plant growth, releases additional nutrients into the soil. This action leads to greater plant growth and more-demanding species. Weathering also breaks the soil particles down to finer sizes, the smallest of which may be carried downward by percolating water to an underlying soil layer. These finer particles accumulate in the underlying layer, forming the B horizon. Soils in which all three (A, B, and C) layers have formed are termed *mature.*

With continued weathering, nearly all of the mineral nutrients may be released and removed from the soil by plant growth and water percolation. This stage is in many cases accompanied by the development of deleterious acidic by-products. When soil nutrients have been removed or deleterious by-products have accumulated to an extent that retards plant growth, the soil is said to have reached old age. Fortunately, such processes as erosion, flooding, dust storms, and volcanic eruptions expose or provide new, unweathered parent material to begin a new soil life cycle.

Physical and Chemical Composition. The physical and chemical compositions of soil horizons also differ according to the various conditions under which soils develop. These differences form the basis for categorizing soils into different soil groups and types. The five major factors that control the kinds of soil that develop are climate, particularly temperature and precipitation; living organisms, especially the types of native vegetation; the nature of the parent material (chemical and mineralogical composition as well as particle size); topography (ground slope and elevation); and time.

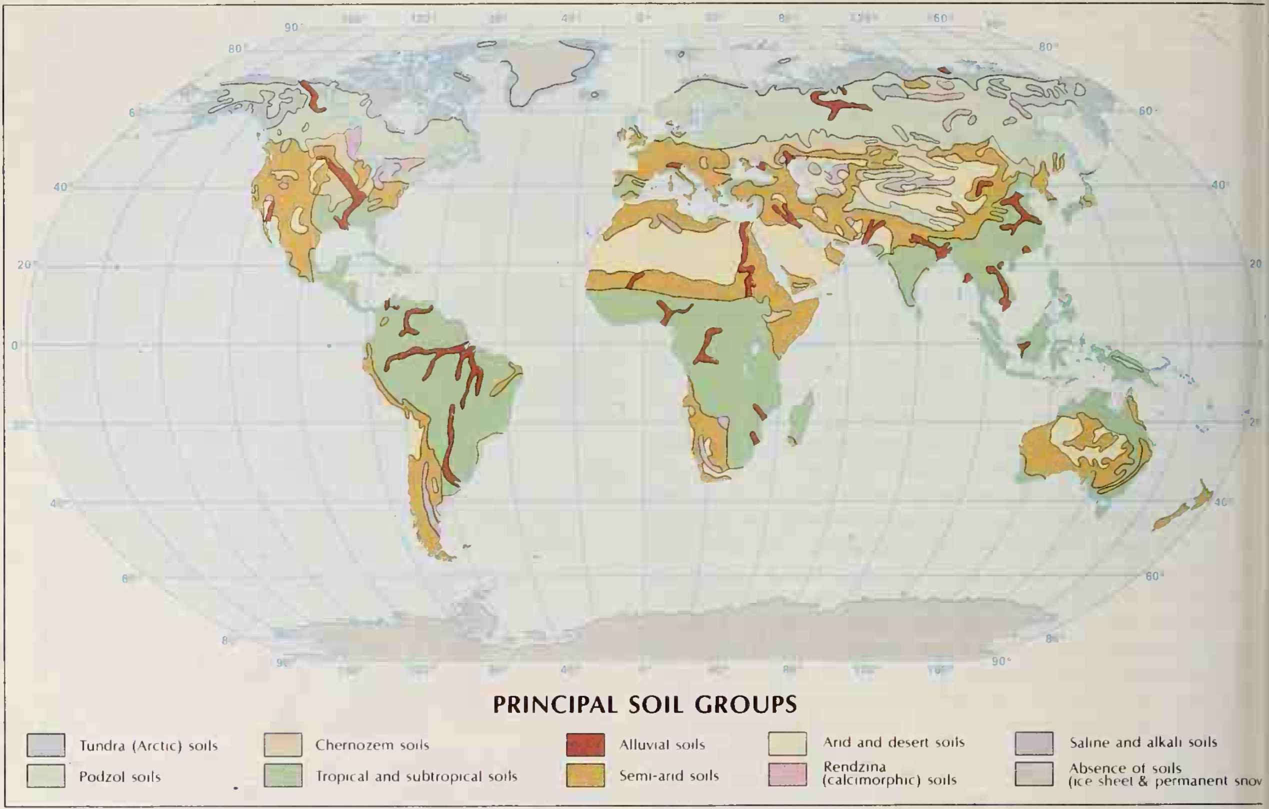
Climate is the most influential of the factors controlling soil development. Part of this influence, however, comes from the control it has on other factors, such as the types of plants that can grow in a given climate. Temperature and precipitation control the rates and types of chemical and physical processes that are active in weathering parent materials. Weathering in turn controls the rate of nutrient release and the profile development. For instance, in arid regions, where the weathering process is slow, soil profiles are much shallower and generally less well developed than in humid regions. Soils in cold regions tend to be shallower than soils in warm regions, and the mineral and organic matter in cold-region soils tends to be less decomposed.



The color of a soil indicates the climatic conditions under which it formed and its composition. The dark soils (1) *of cold tundra regions are derived from humus, or partially decomposed vegetation. Light-colored desert soils* (2) *have little vegetation and humus. The humus-rich earth of semiarid grasslands varies from chestnut brown* (3) *to the black of chernozem* (4) *as rainfall increases. Iron-containing red latosol soils* (5) *are found in tropical grasslands. Acidic podzol soils form in cool humid climates. They include brown deciduous forest soil* (6), *red yellow pine-forest soil* (7), *gray brown deciduous forest podzol* (8), *and gray white mixed pine- and deciduous-forest soils* (9).

Perhaps the second most important factor controlling soil development is living organisms. The rate of organic matter accumulation and, to some extent, of weathering is dependent on plant growth. Chemical composition is in part dependent on the types of plants growing on the soil. For example, the soils that develop under grasslands are chemically different from soils that develop under forests. Even within forested areas different soil profiles develop under conifer trees than under deciduous trees. In places where organic matter is produced faster than it can be decomposed and reused by new plant growth, an organic-rich horizon, or A_0 horizon, develops on top of the soil profile. Such soils are called peats and normally form in marshy or boggy areas.

The type of parent material has a great influence on the texture (particle sizes and shapes) and chemistry of the soil matrix. These factors in turn directly influence soil-profile development. For example, the rate of downward movement of water is controlled in part by the texture of the soil. Also, chemical and mineralogical compo-


PRINCIPAL SOIL GROUPS

sition affects rates of weathering; for instance, olivine minerals weather much faster than do quartz minerals.

Topography affects soil development largely by influencing drainage and erosion. Excess water is removed much more slowly over smooth, flat terrain than over rolling terrain. Water may accumulate in some lowlands and depressions to form swamps, marshes, and bogs (see SWAMP, MARSH, AND BOG). Erosion is more active on sloping ground than on flat ground. Each of these factors influences the depth and character of the soil profile.

Finally, soils evolve with time; soils on relatively new surfaces, such as an eroded area or an area covered by glacial debris from the most recent ice age, may be very different from nearby soils that appear to be in similar settings but have developed on an older landscape surface.

The physical properties of a soil have much to do with its suitability as a medium for plant growth, a fact that has been recognized by farmers from the beginnings of modern civilization. Thus an understanding of basic soil properties, combined with the use of procedures developed by modern technology for managing and improving soils, has led to revolutionary advances in crop production. These advances are necessary to provide food and fiber for a growing world population.

Soil Classification

Many thousands of different soil types are found, ranging from mature soils that have attained equilibrium with their environment to young soils still undergoing development. The factors involved in producing any soil type include the parent rock materials, the landform of a given region, its climate, the local ecology, and the time period over which these other factors have been operating. Wherever the combination of these factors is similar, the resulting soils will also be similar.

Classification Systems. A variety of classification systems have been developed for grouping soil types. The oldest were based on use—that is, on the suitability of soils for various forms of agriculture. Scientists in the United States in the 19th century attempted a geological approach, using the underlying and presumably parent rock as the basis for classification. In the later 19th century, however, Russian agriculturists began to develop grouping methods, based on field and laboratory studies of distinctive soil properties as well as on broad climatic differences, that have influenced all subsequent approaches. The development of such systems remains an ongoing field of activity.

Group Characteristics. The soil groups that appear in the accompanying map can be equated with the latest classifications and characterized as follows.

TUNDRA soils (histosols and inceptisols) have dark brown surfaces and darker subsoils that, in arctic regions, are underlain by PERMAFROST. The soils can be farmed if they are well drained and permafrost is absent or deep-lying.

Podzol soils (spodosols and alfisols) are moderately to strongly leached soils typical of forested, humid regions. They are not naturally very productive for agriculture but can be made so through good land management and heavy application of fertilizers.

Chernozem soils (mollisols) have a dark surface layer underlain by more lightly colored soil. They typically develop under grasses in temperate to cool, subhumid climates and are highly productive, although they require fertilizers after longer use. In some classification systems, chernozems shade into both the subtropical and the semiarid zones depicted on the chart.

Tropical and subtropical soils that are intensely weathered, reddish, and leached are referred to as LATERITES (oxisols). They form under conditions of good drainage, high temperatures, and extensive rainfall. When exposed, however, such soils tend to harden into an agriculturally useless material. Less intensely weathered varieties (ultisols) are highly productive when fertilized.

True DESERT soils (aridisols) are light colored, shallow, and low in organic matter. In some locations they have lateritic characteristics, but under irrigation other types of desert soils can be made highly productive.

The remaining soil groups on the map are intrazonal or azonal, such as the alluvial soils (entisols) deposited by major rivers and the saline and alkali soils found in desert regions. Rendzina soils resemble chernozems but are underlain by chalk or soft limestone at shallow depths.

Soils and Engineering

To the engineer designing a foundation or a dam, the materials making up the Earth's crust are divided into the categories of soil and rock. Soil is a natural aggregate of mineral grains often containing some organic particles that can be separated into individual aggregates by such gentle mechanical actions as agitation in water. In contrast, rock is a natural aggregate of mineral grains held together by strong and permanent cohesive bonds; these bonds resist rupture even when subjected to vigorous mechanical actions such as striking the rock with a hammer. What the agronomist terms *soil* extends downward only to about the depth of root penetration, which is seldom more than a few feet. What the engineer terms *soil* extends from the ground surface down to its contact with a layer of hard rock, which in many localities is hundreds of meters below the surface. Engineers who deal with soils are a specialized group of civil engineers known as geotechnical engineers, and the branch of physical science dealing with the mechanical behavior of soils is called soil mechanics.

soil organisms A large and diverse population of organisms resides in the soil and is responsible for such important activities as making nutrients available to plants, weathering soil minerals, decomposing organic waste materials, and detoxifying many environmental toxins that reach the soil. The importance of the soil biota is particularly evident in their extensive involvement in the geochemical cycles of carbon, nitrogen, sulfur, and other elements (see CARBON CYCLE and NITROGEN CYCLE). Their participation in these processes is crucial for soil fertility and plant growth. Not all soil organisms are beneficial, and some may cause plant disease, produce plant toxins, or compete with plants for soil nutrients.

Soil organisms may best be classified on the basis of size into the microbiota (such as algae, protozoans, fungi, and bacteria), the mesobiota (such as nematodes and small arthropods), and the macrobiota (such as earthworms, mollusks, burrowing rodents, reptiles, amphibians, and the roots of higher plants). Most of the vertebrates and insects that inhabit the soil do not remain below the ground all the time, or for their entire life cycle. Although the activity of the mesobiota and macrobiota is important, the soil microbiota are generally considered of greater significance in nutrient cycling, mineral weathering, and other biological activities.

The types and number of organisms present in soil differ from one kind of soil to another because of differences in the chemical and physical characteristics of each soil. Generally speaking, the highest populations and the greatest diversity of population of the microbiota and mesobiota are found in the litter and the top 5 cm (2 in) of a forest soil or in the top 15 cm (6 in) of grassland and agricultural soils.

The region close to a plant root, the rhizosphere, has a higher population of soil microorganisms than does soil away from the plant root because of the availability of many organic compounds leaching from the root or from dead root cells. Consequently, microbial activity goes on at a much more rapid rate in this region. Some fungi in the rhizosphere are able to penetrate the defense mechanisms of plants, forming specialized symbiotic associations with the roots of higher plants called mycorrhizae (literally, "fungus root").

Sokolow, Anna [soh'-kuh-lawv] The works of the American modern-dance choreographer and teacher Anna Sokolow, b. Hartford, Conn., Feb. 9, 1915, are in the repertories of more than a score of dance companies around the world (see MODERN DANCE). Sokolow, raised in New York City's Lower East Side, danced with Martha Graham's company from 1930 to 1939 and presented her own work as early as 1932. Her dances prior to 1954 were on themes of social injustice and have not survived. In 1954, Sokolow created *Lyric Suite*, to the music of Alban Berg; it was the first of several recognized masterpieces. Beginning with this work, she devised dances on emotional themes, in which images of alienation, despair, and mental agony are presented within a virtually abstract framework.

Sol An ancient god of Mesopotamian origin, Sol was introduced into Roman religion in the 3d century AD as the Roman equivalent of the Greek sun-god HELIOS. He was worshiped by the Roman emperors as their principal protector.

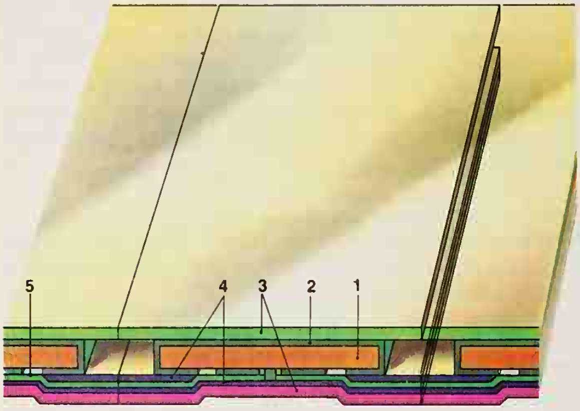
sol see COLLOIDAL STATE

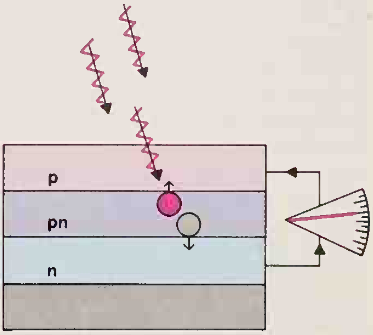
solar cell Solar, or photovoltaic, cells are devices that directly convert sunlight into electricity. A photon of light energy striking a solar cell can release an electron for power production if its energy exceeds the gap energy of the electron. The excess energy of the photon, together with that of all low-energy photons, is dissipated as heat. The efficiency of solar cells is low—about 15 percent for commercial cells, twice as much for experimental cells. Solar cells were first developed by the Bell Laboratories in the 1950s for space applications. They have also been used for remote terrestrial applications—buoys, oil-drilling platforms, and mountaintop microwave repeaters—for which long-distance power lines would be more expensive.

A solar cell consists of two layers of material, one of which is doped with an impurity such as boron to make it negative (n-type), and the other of which is similarly doped to make it positive (p-type; see SEMICONDUCTOR). Because sunlight must penetrate to the junction of the two layers (the p-n junction), one layer must be extremely thin.

Silicon, cadmium sulfide, and gallium arsenide are being used to make solar cells. In recent years the cost of solar cells has fallen from about $50 per peak watt (full sunlight) to less than $5 per peak watt, and the cost continues to fall. When the price falls below $1 per peak watt, solar electricity could be competitive, at least in sunny areas, with conventional methods of power production.

See also: PHOTOELECTRIC CELL; PHOTOELECTRIC EFFECT.





(Above) *In this solar cell, an n-type* (1) *and p-type* (2) *semiconductor are enclosed by plastic layers* (3). *Cells are linked by interconnectors* (4) *separated by an insulator* (5). (Right) *When light enters, it causes electrons and holes to migrate from the pn junction; when the semiconductors are linked, current flows.*

solar constant see SOLAR RADIATION

solar energy Solar energy is a term used to identify the electromagnetic radiation emitted by the Sun and intercepted by Earth. It is the world's most abundant permanent source of energy. The amount of solar energy intercepted by Earth is about 170 trillion kilowatts (kW), an amount 5,000 times greater than the sum of all other energy inputs such as terrestrial nuclear energy, geothermal energy, and gravitational energy. About 30% of solar radiation is reflected into space, 47% is converted to heat on Earth and reradiated to space, and 23% powers the evaporation-precipitation cycle of the biosphere. The amount of the Sun's energy intercepted by Earth is only one-thousandth of one-millionth of the total released by the conversion of 4 million tons of hydrogen per second to helium in the Sun.

The practical uses of solar energy on Earth include solar heating for buildings, solar heat for industry, and electricity production from solar energy.

The Solar Resource

Because of the dilute nature of solar energy, relatively large areas are needed to collect it, and in northern climates solar systems for heating or electricity production may cost more than systems using fossil or nuclear fuels. However, when using properly designed and constructed systems, solar energy is competitive with other energy sources in many parts of the world. For example, solar heating of both buildings and domestic hot water is cheaper than electric heating in many parts of the United States.

Most applications of solar energy rely on systems consisting of collectors, storage, and controls. Storage is often needed because solar energy is only available during daylight hours, but the demand for energy may be continuous. Controls are needed to ensure that the collection and storage systems operate safely and efficiently.

The availability of solar energy is determined by three characteristics of a particular site: (1) location as measured by latitude, longitude, and altitude, (2) time of year, and (3) local weather conditions. As one would expect, solar energy levels are lower the farther north the site. In addition to geography, season is an important determinant of solar energy levels, because the position of the Sun and the weather vary greatly from summer to winter. Solar-systems designers tilt solar-collection surfaces to favor the position of the Sun during the part of the year when energy is most in demand.

Simple Applications of Solar Energy

The Sun's rays have long been used as the heat source for evaporating and distilling water. Solar evaporation has always been an important salt-production process. Salt water is pumped into shallow ponds that are open to the Sun. As the water evaporates, its salts form crystals that settle at the bottom and are eventually collected.

Producing drinkable water from brine is accomplished in a solar still, where salty water is evaporated. The salt becomes concentrated in the bottom of the still basin, while the water vapor rises, condenses on the still cover as fresh water, and is drawn off.

The solar cooking stove has become an important device in tropical countries where firewood is in short supply. The stove may be simply a hot box, an insulated container, perhaps with a mirrored cover that intensifies the Sun's heat. More complex stoves have reflectors that focus sunlight directly on the cooking area, or they use separate heat-collector devices that transfer heat to water inside a steam cooker.

Solar heat is also used throughout the world to dry agricultural crops, fruits, and vegetables.

Solar Energy Use in Buildings

Both water and space heating are among the most successful small-scale applications of solar energy. Thousands of systems of these types have been installed throughout the world.

Solar Collectors. Solar collectors are devices that absorb solar energy and produce heat. They are mounted on the roofs of buildings or in other areas that are open to direct sunlight, and they are used for space heating and cooling and for heating water.

The flat-plate collector is made of a copper, aluminum, or steel heat-absorber plate, the surface of which is blackened to make the plate more efficient in absorbing solar heat. A heat-transfer liquid—usually a water-and-antifreeze solution—circulates through a set of tubes and removes heat from the plate. The tubes may be attached to the plate, or passageways for liquid or air may be incorporated into the plate itself, or the heat-transfer medium may simply flow across the surface of the plate.

To minimize convective and conductive heat losses into the atmosphere, two layers of glass or transparent plastic, separated by an air space, are placed above the plate. The cover layers also minimize reradiation from the collector. To reduce heat losses further, the back and sides of the collector are heavily insulated, as are all pipes and ducts leading to and from the heat-storage area.

Evacuated-tube collectors consist of two glass tubes, one within the other, with a vacuum between the tubes to minimize heat loss. Because the tubes are round and are backed with reflecting material, this type of collector can absorb more sunlight and has a significantly higher overall efficiency than the flat-plate collector. Evacuated-tube collectors are used in northern climates where light intensities are low.

Concentrating, or focusing, solar collectors focus the Sun's rays on a tube (trough type), a point (dish type), or a concave mirror to provide higher temperatures for special purposes, such as industrial-process heat. Such collectors must be able to move both vertically and horizontally in order to track the Sun across the sky in all seasons.

Solar Water Heating. Solar water heating is an old and simple application of solar heat, and an inexpensive system for many buildings. The most common system consists of a collector located outside the building and tilted at an angle that favors uniform yearlong solar input. (The tilt angle is approximately equal to the local latitude.) In addition to the collector, there is a small fractional-horsepower pump for water circulation and a tank to store the heated water for later use. A simple controller that compares tank and collector temperature operates the pump. Whenever the collector is warmed to a temperature greater than that of the tank, the pump is turned on.

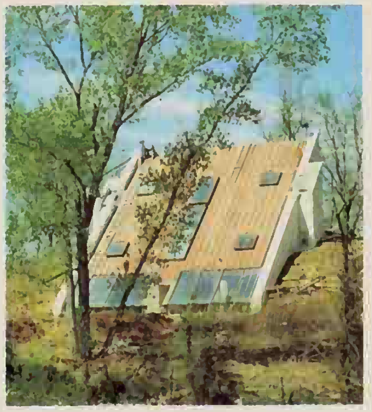
Active Solar Space Heating. Most of the heating energy used in residences is for space heating, that is, for providing the heat needed to maintain comfort within a building. Solar energy is a good match for this heating task because it is able to produce heat at temperatures close to those needed for heating buildings. In addition, the amount of solar energy falling on the roof of a properly oriented residence is roughly equivalent to what is needed to provide space heat.

A typical space-heating system consists of a roof-mounted collector array whose tilt angle is equal to the local latitude plus 15°, a heat-storage tank or bin, pumps or a fan, and a network of pipes or ducts through which the heat is distributed.

Active systems use either a liquid (again, the most common is a mixture of water and antifreeze) or air as the heat-transfer medium. Insulated channels carry the heat-transfer medium to the collector panels to absorb heat, and then to an insulated storage tank for water-based systems, or an insulated bin of a heat-retaining material such as rocks or pebbles for an air-based system. The heat is transferred to the storage medium, and the cooled heat-transfer medium is returned to the collectors.

An auxiliary heat source is used in periods when solar heat is not available. A control system operates the pumps or fans and the auxiliary heat source.

Because large solar-heating systems are expensive to buy and install, other measures for reducing the need for conventional energy are also undertaken. It is almost always best to insulate and tighten a building before installing a solar system on it.



An increasing number of houses, such as this one, are being designed and built to make use of solar energy for heating. Flat-plate solar collectors cover the south-facing roof, set at an angle that catches the winter sun most efficiently.

Passive Solar Space Heating. Passive systems avoid the use of mechanical components. The simplest passive system, the direct-gain system, involves larger-than-normal south-facing windows, with a massive floor slab that serves as the heat storage. This system is particularly effective in bringing up the temperature of a house quickly in the morning, but it can cause overheating problems in sunny climates if sufficient storage is not available.

The thermal storage wall avoids some of the shortcomings of the direct-gain system by interposing a massive wall—of concrete about 20–30 cm (8–12 in) thick—in the heated space next to the windows. The wall stores heat for night heating, while air circulation transports heat from the windows during the day.

Passive systems have been more widely adopted than active systems for space heating, because they are simpler and less costly. In climates where heating is necessary, good architectural practice always includes some measure of passive solar heating, often with features of both of the approaches described here.

Solar Energy in Industry

Temperatures sufficiently high to be of use in industry can be achieved using solar heat. In addition, the technology for converting solar radiation directly into electricity is proving more practical every year.

Solar Process Heat. In order to produce high temperatures, sunlight must be focused or concentrated via an optical focusing system. In one such system a parabolic "dish" focuses solar radiation onto an absorber, concentrating sunlight by a factor of over 100 to produce temperatures exceeding 538° C (1,000° F). If such high temperatures are not needed, smaller degrees of concentration can be obtained. Although not widely used, solar industrial-process heat systems have been effective in the food processing and other industries with moderate temperature needs.

Solar-Thermal Power Production. The high temperatures produced by concentrating solar collectors can be used to produce steam, which in turn can drive a turbine to produce electric power. A number of solar power plants have been built, although they are quite small relative to the normal fossil fuel or nuclear power plant. The technology has been shown to be reliable but more expensive, in most cases, than conventional technology. A successful and economical 194-megawatt solar power plant has been constructed in the desert of southern California, however.

Solar power plants are of particular interest to those utilities which have their maximum demand as a result of air-conditioning loads drawn off by homes and office buildings. Solar plants produce maximum output during sunny periods of the summer, just when this particular demand is greatest.

Photovoltaic Conversion. The use of large fields of concentrating collectors has certain drawbacks, including the need for extensive piping, hundreds of leakproof fittings, and steam turbine-generators to actually produce electricity. A more straightforward approach is based on using photovoltaic cells, or SOLAR CELLS, which convert sunlight directly into electricity. The solar cell is a specially constructed semiconductor device fabricated from exceptionally pure silicon. Small portions of carefully selected impurities are added to produce a region where light energy breaks electron bonds, creating free charges. These charges migrate, producing current. The amount of current depends on the amount of solar radiation and the size of the cell. By connecting a number of cells in an array, any desired current and voltage level can be produced. (See also PHOTOELECTRIC EFFECT.)

Since the 1950s, France has been putting solar energy to novel use at a facility near Mount Louis in the French Pyrenees. Reflectors there collect the Sun's rays to achieve sustained high temperatures. The photograph shows some of the 63 separate mirrors that individually track the Sun by means of photoelectric equipment.

The efficiency of solar cells in the late 1980s was in the 12–15% range: that is, only 10–15% of the incident sunlight is actually utilized. However, cells with twice that efficiency have been tested, and significant gains in the efficiency of commercial cells arrived with the 1990s.

Single solar cells today power pocket calculators. Small arrays keep batteries charged, and they power irrigation pumps and refrigerators in areas where there is no commercial electricity. A solar-power generating station near San Luis Obispo in California contains a solar-cell array that powers 2,300 homes.

Other Forms of Solar Energy

The energy applications discussed above all make direct use of solar energy as it strikes the Earth. There are also important indirect applications, where solar radiation is converted into other usable energy forms. For example, the Sun's energy profoundly affects the world's wind patterns, causes ocean water to evaporate as part of the hydrologic cycle, and is essential for plant growth. The hydrologic cycle makes HYDROELECTRIC POWER possible. Vegetation can be burned directly—for instance, as wood in a stove—or made into other forms of fuel in a process known as biomass conversion. The winds are used to turn windmills (see WINDMILLS AND WIND POWER). Solar energy also makes it possible to harness OCEAN THERMAL ENERGY, which uses the temperature difference between Sun-warmed surface water and cold water from the ocean depths to produce power.

solar flare see Sun

solar pond A solar, or salt-gradient, pond is a body of water—usually artificial, although a few occur naturally—where dissolved salts create a heat trap that can be tapped both for heat and to produce electricity. The water and bottom material of an ordinary pond, whether freshwater or saline, absorbs heat from the Sun but loses it as the heated water expands and rises to the surface. The addition of salt makes water denser and heavier. If the salt is added at the pond bottom, a salt gradient is created between the surface and the deeper waters.

A typical artificial solar pond has three gradients, or salinity zones. The surface zone, up to 0.5 m deep (1.5 ft), has the lowest salinity. In the middle zone, 1–1.5 m deep (up to 5 ft), salt content increases. The storage zone at the bottom, which may be several meters deep, has the highest salinity and therefore the densest, heaviest water. It is in this bottom layer that trapped heat is stored, and it can be kept stored even at night or beneath winter ice. The salt gradient is maintained by adding salt to the bottom layer and replacing evaporated surface water with fresh water. A well-placed pond can retain between 10 and 20 percent of the solar energy that strikes it.

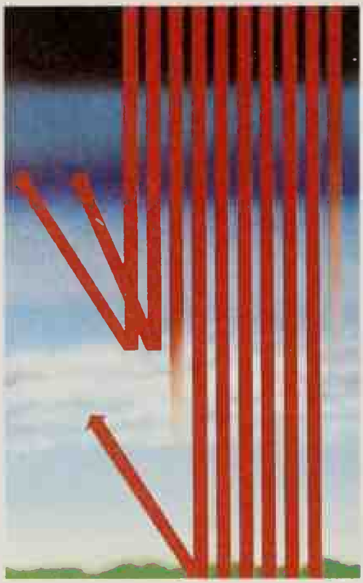
When heat is taken from the pond by passing the hot brine through a heat exchanger, it can be used directly—to heat water or air, for example. The hot brine may also be used to generate electricity.

solar radiation Solar radiation, the electromagnetic radiation emitted by the Sun, is the direct source of all energy and life on Earth. It drives the atmospheric and oceanic currents, evaporates the water that later falls as rain and snow, and induces the plant photosynthesis that provides food, fiber, and fuel.

Only about one two-millionth of all the energy emitted by the Sun is received by the Earth, 150 million km (93 million mi) distant. The solar constant, the average energy from the Sun received at this average distance, is uncertain; recent measurements taken from satellites yield a value of about $(1.373 \pm 0.008) \times 10^6$ erg/sec/cm^2.

When solar radiation enters the Earth's atmosphere, it is partially absorbed and partially reflected, largely by cloud, snowfields, and deserts. The fraction reflected, called the albedo, is variously estimated at 28 to 35 percent for the Earth as a whole. Absorption is by ozone in the stratosphere (see ozone layer), by carbon dioxide, water vapor, clouds, and dust in the troposphere, and by the Earth's surface. Thus, solar radiation is absorbed primarily by water—in the atmosphere, on the surface, and in plants—and nearly half of its energy (a quarter of the total reaching the uppermost level of the atmosphere) goes to evaporate water.

Radiation leaving the Sun is from about 0.2 to 10μ; such wavelengths are fairly close to those of the radiation emitted by a black body at a temperature of 6,000 K. The ozone layer absorbs radiation in the ultraviolet region, and water vapor absorbs radiation in the infrared region and at several parts of the visible region.



Less than half of the solar energy passing through the Earth's atmosphere reaches the surface. For each 100 units of entering radiation (red bars), *about 20 units—consisting mainly of ultraviolet and infrared rays—are absorbed by the ozone layer, water vapor, carbon dioxide, and clouds. About 35 units of visible and infrared radiation are reflected* (red arrows) *from clouds and from the Earth's surface. The average amount of radiation absorbed by the surface is about 45 units.*

solar system The solar system is the group of celestial bodies, including the Earth, orbiting around and gravitationally bound by the star known as the Sun, one of at least a hundred billion stars in our galaxy. The Sun's retinue includes the nine planets Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. In addition it encompasses about 50 satellites (see planet entries), more than 1,000 observed comets, and thousands of lesser bodies known as minor planets (asteroids) and meteoroids (see meteor and meteorite). All of these bodies are immersed in a tenuous sea of fragile and rocky interplanetary dust particles, perhaps ejected from comets at the time of their passage through the inner solar system or resulting from minor planet collisions. Some scientists hypothesize that a tenth planet, called Planet X, is responsible for unexplained perturbations in the orbits of Uranus and Neptune.

The Sun is the only star known to be accompanied by such an extensive planetary system. A few nearby stars are now known to be encircled by swarms of particles of undetermined size, however and evidence indicates that a number of stars are accompanied by giant planetlike objects (see brown dwarf). Thus the possibility of a universe filled with many solar systems remains strong, though as yet unproved.

Dust Rings

The sun is also encircled by rings, or disks, of interplanetary dust. One such ring, lying in the zone between the

CHARACTERISTICS OF THE PLANETS

Planet	*Mean Distance*			*Length of Year (Earth days and years)*	*Length of Day (Earth days, hours, minutes, and seconds*	*Inclination of Axis*	*Inclination of Orbit to Ecliptic Degrees*	*Eccentricity of Orbit*	*Equatorial Diameter*		*Mass (compared to Earth)*	*Density (g/ cm^3)*
	Astronomical Units	*Millions of km*	*Millions of mi*						*km*	*mi*		
Mercury	0.387	57.9	36.0	88 d	58.6 d	7°	7.00	0.2056	4,880	3,030	0.054	5.4
Venus	0.723	108.2	67.0	224.7 d	243 d (retrograde)	3° 24'	3.39	0.0068	12,104	7,517	0.815	5.2
Earth	1	149.6	93.0	365.26 d	23 hr 56 min 4 sec	23° 27'	—	0.0167	12,756	7,921	1	5.51
Mars	1.524	227.9	141.6	687 d	24 hr 37 min 23 sec	23° 59'	1.85	0.0934	6,787	4,210	0.107	3.9
Jupiter	5.203	778.3	483.3	11.86 yr	9 hr 50 min 30 sec	3° 05'	1.30	0.0485	143,000	88,800	317.9	1.32
Saturn	9.539	1,427.0	886.4	29.46 yr	10 hr 14 min	26° 44'	2.49	0.0556	120,000	74,500	95.2	0.7
Uranus	19.218	2,875.0	1,786.0	84.01 yr	23 hr 15 min (retr.)	97° 54'	0.77	0.0472	51,100	31,750	14.58	1.2
Neptune	30.06	4,497.0	2,794.0	164.8 yr	16 hr 3 min	28° 48'	1.77	0.0086	49,500	30,750	17.22	1.67
Pluto	39.44	5,900.0	3,660.0	248.4 yr	6 d 9 hr	> 50°	16.00	0.249	2,200	1,367	0.0026	~1

orbital paths of Jupiter and Mars, has long been known and is the cause of zodiacal light. Another ring was found in the region of the asteroids, between Mars and Jupiter, by the Infrared Astronomy Satellite (IRAS) launched in 1983. Also detected in 1983, by a team of Japanese and Indonesian astronomers, is a third ring only two solar diameters away from the Sun. The dust in this ring is theorized to spiral slowly inward from the outer solar system, because of differential absorption and reradiation of solar energy, until it is vaporized by the Sun and the resulting gases are driven back by the pressure of solar radiation.

Origin of the Solar System

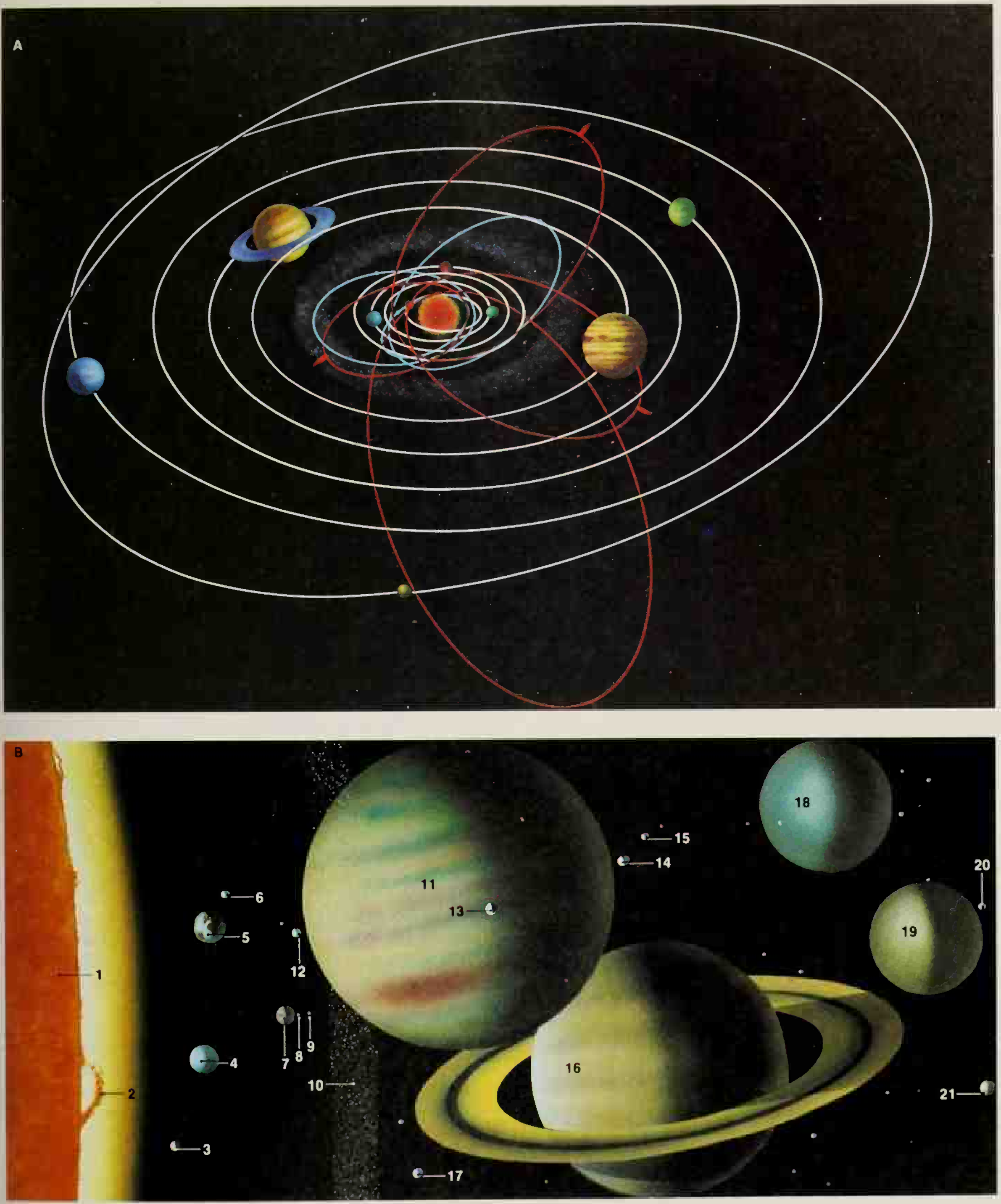
For more than 300 years there has been serious scientific discussion of the processes and events that led to the formation of the solar system. For most of this time lack of knowledge about the physical conditions in the solar system prevented a rigorous approach to the problem. Explanations were especially sought for the regularity in the directions of rotation and orbit of objects in the solar system, the slow rotation of the Sun, and the Titius-Bode law, which states that the radii of the planetary orbits increase in a regular fashion throughout the solar system. In a similar fashion, the radii of the orbits of the regular satellites of Jupiter, Saturn, and Uranus increase in a regular manner. In modern times the slow rotation of the Sun has been explained as resulting from the deceleration of its angular motion through its magnetic interaction with the outflowing solar wind, so that this feature should not have been considered a constraint on theories of the origin of the solar system.

The many theories concerning the origin of the solar system that have been advanced during the last three centuries can be classified as either dualistic or monistic. A common feature of dualistic theories is that another star once passed close to the Sun, and tidal perturbations between the two stars drew out filaments of gas from which the planets condensed. Theories of this type encounter enormous difficulties in trying to account for modern information about the solar system, and they have generally been discarded. By contrast, monistic theories envisage a disk of gas and dust, called the primitive solar nebula, that formed around the Sun. Many of these theories speculate that the Sun and the planets formed together from the primeval solar nebula. This type of theory has dominated thinking about the origin of the solar system since World War II. A photograph taken in 1984 of a nearby star, Beta Pictoris, appears to show a solar system forming in this way from a disk of surrounding material.

The large amount of activity that has taken place in the last 20 years in the renewed exploration of the solar system has also provided a great impetus for renewed studies of the origin of the system. One important component of this research has been the detailed studies of the properties of meteorites that has been made possible by modern laboratory instrumentation. The distribution and abundance of the elements within different meteoritic mineral phases has provided much information on the physical conditions present at the time the solar system began to form. Recent discoveries of anomalies in the isotopic compositions of the elements in certain mineral phases in meteorites promise to give information about the local galactic interstellar environment that led to the formation of the solar system. Investigations of the properties of other planets has led to the new science of comparative planetology, in which the differences observed among the planets not only lead to a better understanding of the planets, but also pose precise new questions concerning the mechanisms by which the planets may have been formed.

Studies of the stars within our galaxy have shown that the age of our galaxy is much greater than the age of the solar system. Therefore, processes observed in the formation of stars within our galaxy today are likely to be found relevant to the formation of our solar system. Stars appear to form in groups or associations, as a result of the gravitational collapse of clouds of gas and dust in the interstellar medium. Modern monistic theories envisage the gas and dust in the primitive solar nebula to be the collapsed remnant of such materials.

There has been much discussion of how the planets might have formed from the primeval solar nebula. In recent years attention has focused on the possibility that two types of gravitational instabilities might have played an important role in this process. One type is a



A diagram of the solar system (A) *reveals that the four inner planets* (spheres) *are concentrated in nearly circular orbits* (white curves) *close to the sun* (red), *whereas the five outer planets are spread over larger distances. Of all the planets, the orbit of Pluto—the farthest known planet—is the most eccentric and the most highly inclined to the ecliptic, or the plane of the Earth's orbit about the Sun. Pluto's orbit periodically falls inside that of the planet Neptune. Most of the asteroids lie within a belt* (dotted band) *between the inner and the outer planets. Some of the asteroids* (blue curves) *and most of the comets* (red curves) *have highly inclined and eccentric orbits. In a diagram* (B) *of the Sun* (1) *and the planets drawn to the same scale, the Sun's size is indicated by comparing a solar prominence, or jet of glowing gases* (2), *with the inner planets Mercury* (3), *Venus* (4), *Earth* (5) *with its Moon* (6), *and Mars* (7) *with its tiny moons Phobos* (8) *and Deimos* (9). *The asteroid belt* (10) *is found between Mars and the outer planet Jupiter* (11) *with its four largest, or Galilean, satellites, Io* (12), *Europa* (13), *Ganymede* (14), *and Callisto* (15). *The other outer planets are Saturn* (16), *which is shown with its rings and its satellites, the largest of which is Titan* (17); *Uranus* (18), *with its five largest satellites; Neptune* (19), *with Triton* (20), *the largest of its two moons; and Pluto* (21).

gravitational instability in the gas of the primitive solar nebula, from which there would be formed giant gaseous protoplanets whose evolution could lead, in the outer solar system, to the giant planets observed today. In the inner solar system, giant gaseous protoplanets could have formed rocky cores at their centers, which survived the stripping away of the gaseous envelopes caused by gravitational and thermal forces from the growing Sun.

The other form of gravitational instability involves the condensed materials in the solar nebula. Small dust particles that may have been present in the gas of the solar nebula could be expected to settle toward the midplane of the nebula if the gas were not subject to extensive turbulent churning. Gravitational instabilities acting on a thin dust layer might have formed bodies ranging from tens to hundreds of kilometers in radius. Collisions among these bodies may have played a major role in accumulations of material to form the planets.

Solar Apex

The movement of the solar system as a whole through space is defined in terms of the CELESTIAL SPHERE, the imaginary sphere of the heavens that has Earth at its center. The solar system appears to be moving toward a point on the sphere at a velocity, relative to nearby stars, of about 20 km/sec (12 mi/sec). This point, called the solar apex, lies in the constellation Hercules near the star Vega, at a right ascension of about 18 hours and a declination of about 30° north.

solar wind The solar wind is a continuous outward flow of ionized gas (plasma) from the corona of the SUN, which extends beyond the Earth's orbit and into interstellar space. Measurements from space probes since 1962—the date of its first direct detection—show that its velocity at the Earth's orbit varies between 300 and 700 km/sec (185 and 435 mi/sec).

The charged particles of the solar wind consist mainly of protons and electrons, with 5% by number of helium nuclei. Their total densities range between 1 and 10 particles/cm^3. The magnetic field carried with the wind has a mean intensity at the Earth's orbit of about 5×10^{-5} gauss compared with a maximum magnetic field for the Earth of 0.3 gauss. Probe studies in the ecliptic plane (the line of sight from the Earth to the Sun) show that the mean outflow velocity increases with distance, at least to approximately the Earth's orbit. Relatively little is known about the wind velocity, density, and time dependence out of the ecliptic plane except indirectly from study of its influence on comet tails. This fact makes it difficult to derive an accurate figure for the rate of total mass loss from the Sun, although the loss is estimated at approximately 10^{-13} solar masses per year. This rate is very low compared to that measured in stellar winds of some hot young stars, where loss rates of 10^{-6} solar masses per year have been inferred from observations.

For interactions of the solar wind with the Earth's magnetic field, see EARTH, GEOMAGNETIC FIELD OF; MAGNETOSPHERE.

soldering see WELDING AND SOLDERING

sole Soles are about 117 species of flatfishes constituting the family Soleidae in the order Pleuronectiformes (formerly called Heterosomata). They exhibit the unique FLATFISH pattern of development, with one eye migrating to the other side of the flattened body of the mature sole. They are found mainly in shallow, temperate or tropical, marine waters, but some species, such as the American hogchoker, *Trinectes maculatus*, are common to fresh water. Most species are less than 30 cm (12 in) long, but the common European sole, *Solea solea*—the original Dover sole—grows to about 50 cm (20 in) long. The term *fillet of sole* initially pertained to this fish but is now applied to any flatfish fillet. The lemon sole, *Microstomus kitt*, is a member of the right-eyed flounder family, Pleuronectidae.

The European sole is a warm-water flatfish found in the Mediterranean and the eastern Atlantic.

solenodon [soh-lee'-nuh-dahn] Solenodons are primitive mammals of the family Solenodontidae in the order Insectivora. Only two species still survive, the Haitian solenodon, *Solenodon paradoxus*, and the Cuban solenodon, *S. cubanus*. Solenodons resemble big-footed, rat-sized shrews, reaching about 25 cm (10 in) in length, plus a tail almost equally as long, and 1 kg (2.2 lb) in weight. Like some shrews, solenodons have saliva that is sufficiently toxic to kill one another. Both species are in danger of extinction.

solenoid [soh'-luh-noyd] A solenoid is an electromechanical device consisting of a coil of wire, usually wound in the form of a long, narrow cylinder, and a core, or plunger, made of a magnetic material such as iron placed partly within the coil. When an electric current passes through the coil of wire, the coil becomes an electromagnet, and a magnetic field is created within it. This field exerts a force on the core that tends to pull it further into the coil. The motion of the core can, in turn, be used to actuate some other device such as a switch or relay.

Soler, Antonio [soh-layr'] Antonio Soler, b. November or December 1729, d. Dec. 20, 1783, was a Spanish priest and composer important in the development of the keyboard sonata. He was ordained in 1752 at El Escorial, where he became organist and choirmaster, and shortly afterward studied harpsichord with Domenico Scarlatti. He wrote much church music and some songs, but his best works are his keyboard fugues, fandangos, and especially sonatas, which show Scarlatti's Italian influence while retaining Spanish rhythms. Soler also composed six concertos for two organs.

Soleri, Paolo [soh-lay'-ree] Paolo Soleri, b. Turin, Italy, June 21, 1919, is a visionary designer whose utopian "arcology" "demands a transfiguration of the earth without defiling or disfiguring its own cosmic aspects" by housing human society in a few highly compact megastructures. After emigrating to the United States in 1947 and studying with Frank Lloyd Wright at Taliesin West, Soleri made his home at Cosanti, 113 km (70 mi) north of Scottsdale, Ariz. There, students attracted by his theories pay to help build Arcosanti, a model of the global arcology that Soleri believes to be the only alternative to the destruction of "sclerotic, asphyxiated" human society.

solicitor see ATTORNEY

solicitor general see JUSTICE, U.S. DEPARTMENT OF

solid Solid refers to one of the three basic physical states of matter, the others being liquid and gas. These states are determined by the amount of kinetic energy that the molecules of a substance possess (see KINETIC THEORY OF MATTER). In the case of a solid, molecules have so little energy that they cannot flow past each other. Hence solids maintain their shapes. In a true solid, atoms or molecules are arranged in specific geometries governed by lattice energies and the parameters of electron-bonding orbitals. Such solids are called CRYSTALS; examples are MINERALS and METALS. Solids whose internal atomic arrangements are not regular are termed *amorphous*; examples are GLASS and PLASTICS.

solid solution see MINERAL

solid-state physics Solid-state physics emerged as a separate branch of physics after World War II. Virtually any observable property of solid materials comes under the umbrella of solid-state physics, but research has concentrated on such questions as the magnetic properties, transport properties (electrical and thermal conductivity), superconductivity, Fermi surfaces, atomic arrangement, and electron structure of materials.

Even though there are only 80 elements in sufficient abundance to be used in preparing solid compounds and alloys, there appears to be an unlimited number of ways to combine them and produce materials with unusual properties. Physicists engaged in theoretical solid-state research are unable to predict accurately the properties of pure elements, compounds, and alloys, because these fundamental properties arise from the complexity of their electronic structure. Thus new materials are generally discovered from the empirical effort of mixing elements under varying conditions of heat, pressure, and so on.

Typical data determined by solid-state physicists on a material are its crystal structure, density, electrical conductivity, thermal conductivity, magnetic structure, compressibility, coefficient of expansion, and specific heat. The identification of these measurable properties and their variation with temperature has been a major concern to solid-state physicists. Because measurable properties evidence similarities in various materials, solid-state physics has been traditionally but not rigidly subdivided into groups concerning themselves principally with metals, insulators, or semiconductors. There is a vast group of solids, however, such as plastics, organic materials (wood and bone), and rocks, that has received less attention because these solids have much more complex atomic arrangements and are therefore more difficult to understand. It is implicit that the solid-state physicist is dedicated to developing the relationship between measurable properties of solids (and even liquids) and their electronic structure.

The principal experimental techniques employed in solid-state physics are photon and neutron scattering and absorption to examine atomic positions, magnetic properties, atomic vibrations, electron positions, electron velocities, and electron energies; and the application of electric and magnetic fields and heat (or removal of heat) and pressures, accompanied by measurements of their effects.

A major problem that has challenged solid-state physicists is magnetism. It is not known why only four of all the naturally occurring elements in the periodic table are ferromagnetic: iron, cobalt, nickel, and gadolinium. Even in the case of iron, only the commonly stable arrangement (α iron) is ferromagnetic. Even though these forms have been studied extensively, the theoretical physicist is unable to calculate these differences. On the other hand, cobalt has two crystal forms that have almost identical ferromagnetic strength.

From a variety of measurements and limited theoretical understanding, the following is known about ferromagnetism: every electron is an individual magnet, but in most of the elements the electrons pair off with their north and south poles oppositely aligned. For example, in aluminum or copper any experimental technique that can find the magnetic field on one individual electron, such as neutron scattering, reveals that the electrons pair off so well that their magnetic fields cancel exactly. Even in α iron, 24 of the 26 electrons on each atom pair off, but two of them do just the opposite and maintain their north poles rigidly fixed in the same direction. This orientation is maintained up to the boiling point of 3,000° C (5,432° F). The magnetic strength of each electron is thousands of times too weak to account for such a strong adherence to this arrangement. Additionally, this pair of electrons on one atom is rigidly fixed to the pairs on all other atoms. It is the total magnetic field from all these pairs that enables a magnet to lift a piece of iron. Even the force that keeps these pairs all pointing in the same direction cannot be overcome until a temperature of 776° C (1,429° F) is attained.

The answer to the origin of magnetism lies in the mysteries of the Fermi-Dirac principle, which states that only pairs of electrons, each with north pole opposite, can occupy the same energy level in atomic systems. This is a powerful force and accounts for the different quantized energy levels on atoms. On each atom in α iron, the magnetic pair of electrons is actually in different energy levels; otherwise their magnetic north poles would have to be opposite. They can exist in these two particular different energy levels because the electrons are relatively far from each other on the atom; this separation reduces the electrostatic repulsion between like charges. Thus the Fermi-Dirac principle and electrostatic forces, which are thousands of times stronger than the magnetic forces, combine to produce magnetism. Only in a few elements are conditions just right to take advantage of these forces and produce ferromagnetism.

See also: CONDUCTION, ELECTRIC; CRYOGENICS; MAGNETISM; METAL; SEMICONDUCTOR; SUPERCONDUCTIVITY; TRANSISTOR.

Solidarity Solidarity (Polish: Solidarność) is a Polish political movement that in 1989 won the first free election held in a Soviet-bloc country. Founded in September 1980 as a labor union by strikers at the Gdańsk shipyards, Solidarity was headed by one of the strike leaders, Lech WAŁESA. During the last months of 1980 and throughout 1981, it took on an increasingly revolutionary character, pressuring Poland's Communist government to enact democratic reforms. Rural Solidarity, a farmers' union, was founded in April 1981. Outlawed by the government in December 1981, Solidarity functioned as an underground movement for several years. It resumed open activity in 1988, after the spirit of *glasnost* emanating from the USSR had created a freer atmosphere in Poland. Its candidates won a majority in the parliamentary elections of June 1989, and in August a coalition government was formed under a Solidarity premier, Tadeusz Mazowiecki. In December 1990, Mazowiecki was defeated by Wałesa in a runoff election for the presidency. Wałesa named Jan Krzysztof Bielecki premier; with his confirmation on Jan. 4, 1991, by Poland's lower house of parliament, the reins of government were firmly in the hands of Solidarity.

solipsism [soh'-luhp-sizm] Solipsism is the philosophical view that only the self exists or can be known to exist. In its most extreme form, solipsism holds that all perceived objects and events are merely the products of personal consciousness and that this consciousness alone is genuinely real. Most forms of solipsism, however, are derived from SKEPTICISM and argue that the only things of which genuine knowledge is possible are the mind and its contents; hence these alone may justifiably be said to exist. A variant of this form argues that only in the first-person case is knowledge of the mind possible.

solitaire (bird) Solitaire is the common name for about nine species of robinlike songbirds of the thrush family, Turdidae. Native to the New World, solitaires are found mostly in the tropics, but Townsend's solitaire, *Myadestes townsendi*, occurs west of the Rocky Mountains, wintering from northern Mexico into southern Canada and breeding as far north as southern Alaska. Smaller and slimmer than the closely related American robin, it is gray, with a buff wing patch, white eye ring, and white outer tail feathers. Two Caribbean islands species, the Cuban solitaire, *M. elisabeth*, and the rufous-throated solitaire, *M. genibarbis*, are considered endangered species. Solitaire is also the common name for two species of extinct DODO BIRDS.

Townsend's solitaire, a small perching songbird that resembles a mockingbird, is found in coniferous forests and brushlands west of the Rockies, from Alaska to Mexico.

solitaire (card game) A CARD GAME intended primarily for one player, solitaire, or patience, exists in some 350 different forms, each with its own rules and methods of play. (Solitaire is also the name of a pegboard game in which the object is to remove all the pegs but one from the board by jumping pegs in a prescribed manner.) The basic aim of all solitaires is to lay out a certain number of cards from a 52-card deck, and then to play the remaining cards in such a way that all the cards will eventually be laid out in predetermined sequences or combinations.

The most popular solitaire is called klondike, or canfield. Others are pyramid, fortress, spider, gold, and idiot's delight (or aces up). In solitaires played by two persons the best known are Russian bank and spite and malice.

soliton In physics, a soliton is a solitary wave that does not readily disperse while it is moving. A unique balance between two physical effects—one that dissipates the wave and one that builds up the wave—causes a soliton to maintain its energy and form for a much longer time than does an ordinary wave. Solitons were predicted by the mathematical theory of QUANTUM MECHANICS and have only recently been observed in many physical systems. They have been observed on the surface of water as well as in the depths of the ocean.

In theory, two colliding solitons should pass through each other with no net effects. Theorists also predict that a soliton may exist on the quantum level as a discreet particle with distinct properties, such as single magnetic charge (see MONOPOLE, MAGNETIC). Recently, LASER light has been produced in soliton form.

See also: WAVES AND WAVE MOTION.

Sologub, Fyodor [suh-luh-goop'] A novelist of genius and a poet of high distinction, Fyodor Sologub, b. Fyodor Kuzmich Teternikov, Mar. 1 (N.S.), 1863, d. Dec. 5, 1927, was a major figure of Russian symbolism. A high school teacher and administrator until 1907, he possessed a sensitive but perverse intellect. His masterpiece, *The Little Demon* (1907; Eng. trans., 1916), concerns an evil schoolteacher. His trilogy, *The Created Legend* (1908–12; Eng. trans., 1916), mixes realism and fantasy.

Solomon, King of Israel The son and successor of King David, Solomon was the third king of Israel, reigning from about 972 BC until his death in 922. David's son by Bathsheba, Solomon was unexpectedly elevated to the throne after his half brother Adonijah had attempted unsuccessfully to seize the kingship. The young Solomon quickly mastered the situation, ruthlessly eliminating all the potential threats to his rule.

Solomon's reign was marked by foreign alliances, especially with Egypt and the Phoenicians, and by military strength, and was thus untroubled by major wars or internal revolts, leaving him free to pursue other interests. Solomon fully exploited the economic possibilities of his empire and used the resulting wealth to support vast building projects, the most famous being the Temple in Jerusalem. He was also an author and a patron of literature, although many of the writings attributed to him—for example, the Book of Proverbs, Ecclesiastes, and the Song of Solomon—were not his work. Solomon's success in so many spheres contributed to his legendary reputation for wisdom, but his reign ended with simmering resentment over heavy taxes and the religious syncretism fostered by his marriages.

Solomon Islands The Solomon Islands are a chain of seven large and many small islands trending northwest-southeast for 1,500 km (930 mi) in the western Pacific Ocean. Except for the northernmost islands, which are part of Papua New Guinea, the archipelago is politically constituted as an independent state within the British Commonwealth. The capital is Honiara, on Guadalcanal. Most of the islands are volcanic, mountainous, and heavily forested. The highest point in the country is Popomana-

AT A GLANCE

SOLOMON ISLANDS

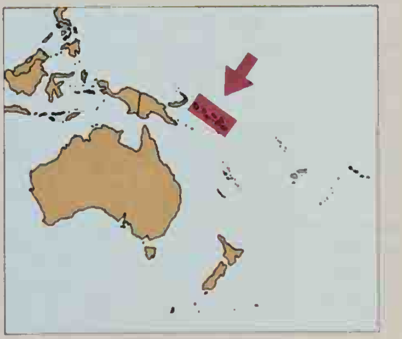
Land: Area: 29,785 km^2 (11,500 mi^2). Capital and largest city: Honiara (1986 pop., 30,499).

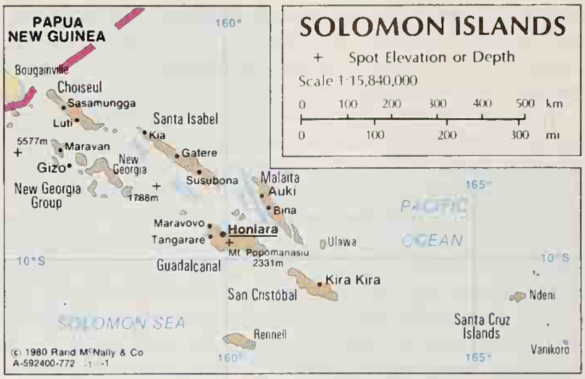
People: Population (1990 est.): 335,082. Density: 11 persons per km^2 (29 per mi^2). Distribution (1986 est.): 16% urban, 84% rural. Official language: English. Major religions: Protestantism, Roman Catholicism.

Government: Type: parliamentary state within the Commonwealth. Legislature: National Parliament. Political subdivisions: 7 provinces, 1 town.

Economy: GNP (1989): $181 million; $570 per capita. Labor distribution (1986): agriculture—46%; public administration and services—24%; trade—8%; transportation and communications—5%; manufacturing—2%; construction—6%. Foreign trade (1988): imports—$101.7 million; exports—$80.1 million. Currency: 1 Solomon Islands dollar = 100 cents.

Education and Health: Literacy (1986 est.): 60% of adult population. Universities (1987): 1. Hospital beds (1986): 1,479. Physicians (1988): 31. Life expectancy (1990): women—72; men—67. Infant mortality (1990 est.): 40 per 1,000 live births.





siu (2,440 m/8,005 ft), on Guadalcanal. Rainfall exceeds 2,500 mm (100 in) annually; temperatures average 27° C (80° F) throughout the year.

The population is predominantly Melanesian. The Solomon Islands campus of the University of the Pacific opened in 1977. Health clinics are being built to provide basic care. Tuberculosis and leprosy remain major health problems.

Agriculture is the mainstay of the economy. Bananas, coconuts, cacao, and rice are grown, and livestock is raised. Fish, timber, copra, and palm oil are exported. No major commercial mining has taken place, but large deposits of bauxite, copper, phosphates, and nickel are known to exist.

The first European to visit the Solomons was a Spaniard, Álvaro de Mendaña de Neyra, in 1568. The name is derived from Mendaña's belief that the islands were the source of King Solomon's gold for the Temple in Jerusalem. Periodic sightings were made of the islands, but the hostility of the indigenous population prevented European settlement. A British protectorate was established over the Southern Solomons in 1893, and the high commissioner for the Western Pacific assumed control in 1877. By 1900 the present political composition of the Solomon Islands had been established. Following World War II, a period of opposition to British rule set in under the Marching Rule movement. Self-government was achieved in 1976. Full independence was granted in 1978, with the British monarch as head of state and a prime minister elected from parliament as head of government. Peter Kenilorea, the nation's first prime minister, held the office for most of the decade following independence. In 1986 the islands were devastated by Typhoon Namu.

Solomon's seal Solomon's seal, genus *Polygonatum*, is any of about 30 species of wildflowers belonging to the lily family, Liliaceae. The plant has a tall, slender stem and alternate leaves and bears bell-shaped flowers and red or blue-black berries. Its young shoots and rootstock are edible. Solomon's seal is common to woodlands throughout North America and Europe.

Solon [soh'-luhn] Solon, *c.*639–*c.*559 BC, was an Athenian statesman who as archon in 594 BC was granted absolute authority to remedy the grave ills then afflicting Athens. A serious economic crisis had forced many Athenians into debt or slavery. The monopoly of the aristocracy excluded many well-to-do people from participating in government. To stave off revolution or tyranny, Solon canceled all debts and forbade debt-slavery. He made wealth, not birth, the criterion for public office by establishing four income classes and according political rights to members of the top three classes on a graduated scale. Solon also passed sumptuary legislation, and he modified the Athenian system of weights and measures, perhaps causing inflation. He may also have established an Athenian council or senate (consisting of 400 members of the propertied classes) whose purpose was to prepare proposals that were later voted on by the people sitting in assembly (the *ekklesia*). After completing his reforms, Solon left Athens to travel abroad. He died shortly after Peisistratus became tyrant.

Soloviev, Vladimir Sergeyevich [suh-luhv-yawf'] A Russian philosopher, poet, and publicist, Vladimir Sergeyevich Soloviev, b. Jan. 28 (N.S.), 1853, d. Aug. 13 (N.S.), 1900, intellectually dominated the Russian religious revival at the beginning of the 20th century. In 1877 he delivered his famous lectures *On Godmanhood*, in which he presented an elaborate cosmological and theological system, criticizing Eastern Orthodoxy for forgetting humanity and Western Christianity for neglecting God. In his later years Soloviev moved toward the mystical and gnostic doctrine of Sophia ("Wisdom"), a substantial reality uniting God and creation. This conception led him to advocate a synthesis of Eastern and Western Christianity in *Russia and the Universal Church* (1889; Eng. trans., 1948).

solstice see Earth, motions of

Solti, Sir Georg [shohl'-tee, gay'-ohrg] Sir Georg Solti, b. Oct. 21, 1912, made his conducting debut (1933) in his native Hungary with the Budapest Opera. During World War II he lived in Switzerland, performing as a pianist. After the war he conducted the Munich State Opera (1947–51) and the Frankfurt Opera (1951–61) and became music director (1961–71) at Covent Garden, London.

The high point of Solti's career came with his directorship (1969–91) of the Chicago Symphony Orchestra. Under his leadership it regained the success it had enjoyed under Fritz Reiner and became known as one of the world's greatest orchestras. He also served (1971–75) as music director of L'Orchestre de Paris and as the principal conductor and artistic director (1979–83) of the London Philharmonic.

solubility The solubility of a substance is the amount of substance required to form a saturated solution with a solvent. For example, the solubility of salt (NaCl) in water is 37 grams of NaCl per 100 grams of water at room temperature. The solubility is therefore a property of a pair of substances and is, in general, temperature dependent.

Solution theory is not advanced enough to be able to predict solubilities. General structural chemistry can be applied, however, to predict relative solubilities of materials in a given solvent. When discussing liquids, the statement that "like dissolves like" is a useful general rule. "Like" in this sense means "structurally similar." An example is ethyl alcohol (C_2H_5OH), which is miscible with water (HOH). These two molecules each have the structurally similar OH group. For other alcohols, as the length of the carbon chain increases the alcohol becomes more and more unlike water and, therefore, progressively less soluble in water. The principle thus provides a satisfactory general qualitative means of predicting relative solubilities of substances.

solution In chemistry, a solution is a homogeneous mixture of two or more substances. It may be gaseous, as air; liquid, as seawater; or solid, as a nickel coin. In each case, one substance is uniformly dispersed throughout another; its particles are molecular in size.

The substance present in the larger proportion is known as the solvent, and that present in the smaller proportion is known as the solute.

Substances that are able to form solutions with each other in all proportions are said to be miscible. Most solutions reach a saturation point after which further addition of solute causes formation of a second phase. Because SOLUBILITY varies with temperature, the saturation point varies similarly. By dissolving a substance with heating, then carefully cooling the solution, a supersaturated solution—one that holds more solute than a saturated solution—can be produced.

See also: PHASE EQUILIBRIUM.

Solvay process see CHEMICAL INDUSTRY

solvent A solvent is a liquid chemical compound used for dissolving other compounds. Solvents are also used for the EXTRACTION of materials from other media, for the purification of solid substances by recrystallization, or as media in which to conduct chemical reactions. Water is one of the most important of all solvents, because it can dissolve many inorganic compounds and some organic substances.

The principal qualification a liquid must possess in order to function as a good solvent is that it be capable of dissolving another substance without reacting with it. A second important characteristic of a solvent is its volatility, as judged by its boiling point. Solvents that have reasonably low boiling points can be removed readily by distillation or evaporation. The recent development of aprotic solvents (polar solvents of moderately high dielectric constant) such as dimethyl sulfoxide, N,N-dimethylformamide, and hexamethylphosphoric triamide has made commercially available a range of high-boiling solvents to function as reaction media at elevated temperatures.

Solzhenitsyn, Aleksandr [sohl-zhuh-neet'-sin] One of the leading Russian writers of the 20th century, Aleksandr Isayevich Solzhenitsyn, b. Rostov-on-Don, Dec. 11, 1918, received the Nobel Prize for literature in 1970. His novels present a vivid account of a man maintaining his freedom against the vicious repressions of a totalitarian regime.

Solzhenitsyn studied mathematics and physics at the University of Rostov-on-Don. He served for four years in the Soviet army and attained the rank of captain in the artillery. His difficulties with the authorities began on Feb. 8, 1945, when he was arrested for having written critical remarks about Stalin in an intercepted letter to a friend. Sentenced without a trial to eight years of hard labor, he remained until 1953 in a number of labor camps (one of which was the setting for *The First Circle*). In 1952 he developed cancer of the skin and was treated (1953) in a hospital in Tashkent (the setting for *The Cancer Ward*).

During the period of de-Stalinization, he was allowed to return to European Russia. He settled in a town southeast of Moscow and taught high school mathematics and physics. The short novel *One Day in the Life of Ivan Denisovich* (1962; film, 1971) was the first of Solzhenitsyn's works to be published in the Soviet Union. It created an instant sensation because its subject is Stalin's forced labor camps. Praised initially, the novel became the basis for further action against the author.

Open conflict erupted with Solzhenitsyn's May 1967 letter to the Fourth National Congress of Soviet Writers, in which he demanded the abolition of censorship, the "rehabilitation" of many writers killed during the purges, and

Photo Jill Krementz © 1975

Aleksandr Solzhenitsyn became a powerful symbol of Russian dissidence when he exposed the Soviet Union's system of labor camps in three novels and a heavily documented study. For his literary indiscretions and political activism, Solzhenitsyn was exiled in 1974 and has since settled in the United States.

the restoration of his personal papers, confiscated by the KGB (secret police) in 1965. The confrontation grew more intense after the publication abroad of *The First Circle* (1968)—the title of which refers to the first circle of Dante's hell—and *The Cancer Ward* (1968–69) and after his winning the Nobel Prize. Further public statements by Solzhenitsyn, as well as the publication of the first volume of *August 1914* (1971) and the first volume of *The Gulag Archipelago* (1973), led the Soviet authorities to exile him to the West in February 1974. Having settled first in Zurich, Solzhenitsyn and his family later moved to the United States. While in the West, Solzhenitsyn completed *The Gulag Archipelago* (3 vols., 1973–78); *The Oak and the Calf* (1975; Eng. trans., 1980), the memoirs of his last ten years in the Soviet Union; *The Mortal Danger: Misconceptions about Soviet Russia and the Threat to America* (1980); and *Three Plays* (1986). In 1989 an expanded version of *August 1914* was published as the first in a projected series of novels about the Russian Revolution, to be called, collectively, *The Red Wheel*. In the same year, *The Gulag Archipelago* was published as a serial in the literary magazine *Novy Mir*, the first Soviet publication of any Solzhenitsyn work since 1963.

Somalia [soh-mahl'-ee-uh] The Somali Democratic Republic is located on the Horn of Africa, the easternmost extension of the African continent. It is bordered by Djibouti, Ethiopia, Kenya, the Gulf of Aden, and the Indian Ocean. Livestock herding is the most important economic activity. Once under both Italian and British rule, Somalia became independent in 1960.

Land, People, and Economy

The country is geographically divided into northern desert and southern coastal plains and plateaus. The northern zone of desert plains rises through a series of hills to the Ogo and Migiurtinia mountains, which reach 2,408 m (7,900 ft) at Surud Ad. The Ogo Plateau extends south from the mountains into the grazing land of the Haud Plateau. In the south the sandy and arid coastal plains lead to the Shebeli-Juba lowlands and plateau with their more temperate climate.

Average annual rainfall totals 76 mm (3 in) in the north and about 300–500 mm (12–20 in) in the south. In summer the northeast coast is brutally hot, with average temperatures of 35° to 38° C (95° to 100° F). In the south the mean annual temperature is about 28° C (82° F), and the humidity is high.

All Somalia's major rivers flow into the Indian Ocean. The main river system is composed of the Juba and Webi Shabeelle rivers, which descend from Ethiopia and flow through the south. The two largest northern streams are the Daror and the Nugaaleed (formerly Nogal); both are ephemeral. Only 13% of the land is arable. Evidence suggests the presence of untapped deposits of uranium, thorium, iron ore, tin, zinc, copper, petroleum, and rare-earth minerals.

AT A GLANCE

SOMALI DEMOCRATIC REPUBLIC

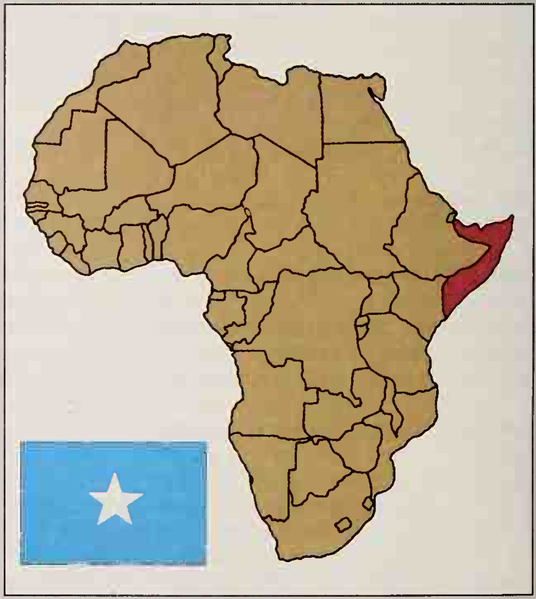
Land: Area: 637,657 km^2 (246,201 mi^2). Capital and largest city: Mogadishu (1981 est. pop., 500,000).

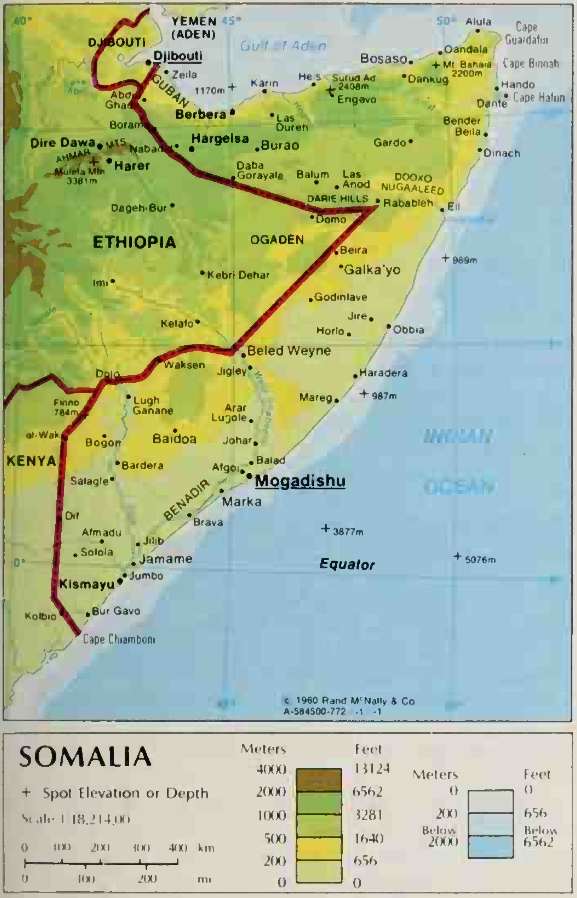
People: Population (1990 est.): 8,424,269. Density: 13.2 persons per km^2 (34.2 per mi^2). Distribution (1989 est.): 33% urban, 67% rural. Official languages: Somali, Arabic. Major religion: Islam.

Government: Type: republic. Legislature: People's Assembly. Political subdivisions: 18 regions.

Economy: GNP (1989): $1.035 billion; $170 per capita. Labor distribution (1985): agriculture—74%; manufacturing, mining, construction, and utilities—9%; government and services—17%. Foreign trade (1988): imports—$354 million; exports—$58 million. Currency: 1 Somali shilling = 100 cents.

Education and Health: Literacy (1985): 12% of adult population. Universities (1990): 1. Hospital beds (1985): 5,536. Physicians (1987): 323. Life expectancy (1990): women—54; men—53. Infant mortality (1990): 125 per 1,000 live births.





Ethnic homogeneity is a marked feature of Somali society. Somalis, who constitute 98% of the country's population, are divided into two groups—the Somal in the north and the Sab in the south. About 70% of all Somalis are nomads who travel with their herds through Somalia, Kenya, and Ethiopia.

Almost everyone speaks Somali (an Afroasiatic language), a written form of which was introduced in 1972. Arabic is also widely used. Nearly all Somalis, who were among the earliest converts to Islam, are devout Sunni Muslims. After MOGADISHU (Somali: Muqdisho), the capital and principal city, the most populous town is Hargeisa. Education is free and officially compulsory, but educational facilities are meager and literacy is low. Health services are also limited.

The nomads' livestock and livestock products are the chief export, with bananas the leading cash crop. Maize and sorghum are the principal food crops. Leather tanneries, shoe factories, and textile mills make up most of the small manufacturing sector. A fishing industry is being developed along the coast. Drought from 1978 to 1981 and again from the mid-1980s, plus the burden of providing for a large indigenous and Ethiopian refugee population, have severely strained the economy. The country has a substantial trade deficit and a large foreign debt and is heavily dependent on foreign aid.

History and Government

In the 7th century Arabs and Persians developed a series of trading posts along the Gulf of Aden and the Indian Ocean. In the 10th century the area was peopled by Somali nomads and pastoral Galla from southwest Ethiopia. For the next 900 years Somalis spread throughout the Horn of Africa. Britain and Italy occupied different parts of the territory in the 1880s, and until World War II, Somalia remained under colonial control. In 1941, Britain occupied Italian Somaliland and in 1948 gave the OGADEN region to Ethiopia, although it was populated largely by Somalis. By 1950 the United Nations had voted to grant independence to Somalia, and in 1960 the two former colonies were united to form the Somali Republic.

Somalia was ruled by a civilian government until 1969, when President Muhammad Siad Barré came to power in a military coup. His Somali Revolutionary Socialist party, created in 1976, formed the executive branch of government. Areas inhabited primarily by Somalis, including Djibouti, the Ogaden, and northeast Kenya, have long been considered lost Somali territories. Somalia invaded the Ogaden in 1977, but Ethiopia regained control of the area, and Soviet forces were expelled from Somalia in 1977 for their support of Ethiopia. The country then received aid (mostly food for its refugee population) from the United States and other Western nations. Sporadic conflict with Ethiopia continued until 1988, when Somalia and Ethiopia signed a nonaggression pact. President Siad Barré, who was reelected in 1986, faced opposition from rebel groups in the north. Riots in the capital in 1989 reflected even more widespread discontent with the government; by early 1990 it was estimated that nearly 500,000 Somalis had fled to Ethiopia to escape the fighting, while another 400,000

Mogadishu, Somalia's capital, largest city, and Indian Ocean port, was established during the 10th century as one of the first of many settlements founded by Arab seafaring traders on the African continent.

were refugees within Somalia. Siad Barré was overthrown on Jan. 27, 1991, but an interim government failed to gain control of the country. By late 1992 up to one-third of all Somalis faced death by starvation due to drought and fighting between various rebel groups, but a UN-sanctioned, U.S.-led deployment of over 30,000 troops gave promise that relief shipments would be protected.

somatotropin see GROWTH; HORMONE, ANIMAL; PITUITARY GLAND

Somerset [suhm'-ur-set] Somerset is a county in southwestern England with an area of 3,451 km^2 (1,332 mi^2) and a population of 450,100 (1991). Bordering on the Bristol Channel in the north, Somerset consists of central lowlands and hilly areas in the west and east. The county town is Taunton. Dairying is the principal economic activity; the Cheddar district is world famous for its cheese. Livestock raising, tourism, fruit growing, the manufacture of woolens and leather goods, and coal and limestone mining are important. Occupied by the Romans in the 1st century AD, the region became part of the Anglo-Saxon kingdom of Wessex in the 7th century. During the English Civil War, Somerset was a royalist stronghold.

Somerset, Edward Seymour, 1st Duke of Known as Protector Somerset, Edward Seymour, b. *c.*1506, d. Jan. 22, 1552, was the virtual ruler of England from 1547 to 1549. Seymour became prominent at court as a result of Henry VIII's marriage to his sister, Jane SEYMOUR, in 1536. He was created earl of Hertford after Jane gave birth to the future EDWARD VI in 1537 and duke of Somerset when Edward succeeded to the throne in 1547. Henry's will provided that England be governed by a group of 16 regents during Edward's minority, but Somerset set this provision aside and assumed sole authority as protector. He fell from power in 1549, primarily because of his inability to suppress Kett's Rebellion, a protest against the enclosure of common land for sheep grazing. Pardoned after a brief imprisonment, he was later charged with treason and beheaded. Somerset favored Protestantism; the first Book of Common Prayer was published during his supremacy. He governed autocratically but is usually considered a liberal in social policy.

Somerville [suhm'-ur-vil] Somerville is a city in Middlesex County, eastern Massachusetts, on the Mystic River. A suburb of Boston, it has a population of 76,210 (1990). The city's industries produce auto bodies, meat products, tools, dies, and paper products. Settled in 1630 as part of Charlestown, Somerville was incorporated in 1842. The first ship built in Massachusetts was launched there in 1631. The first American flag with 13 stripes was flown by Gen. Israel Putnam at Somerville (Jan. 1, 1776). Development of a canal (1803) and rail connections (1835) spurred the growth of industry.

Somme, Battles of the see WORLD WAR I

Somme River [suhm] The Somme River, a 240-km-long (150-mi) stream in northern France, rises northeast of Saint Quentin and flows west to Amiens, and then northwest to the English Channel. The river is paralleled by canals for 72 km (45 mi). The surrounding valley was the scene of heavy fighting in World War I in the First (June 24–Nov. 13, 1916) and Second (Mar. 21–Apr. 5, 1918) Battles of the Somme, as well as in World War II.

Somnus [sahm'-nuhs] In Roman mythology, Somnus was the god of sleep and was identified with the Greek Hypnos. Somnus was the father of Morpheus, the god who shaped dreams, the son of Nox (Night), and the brother of Mors (Death).

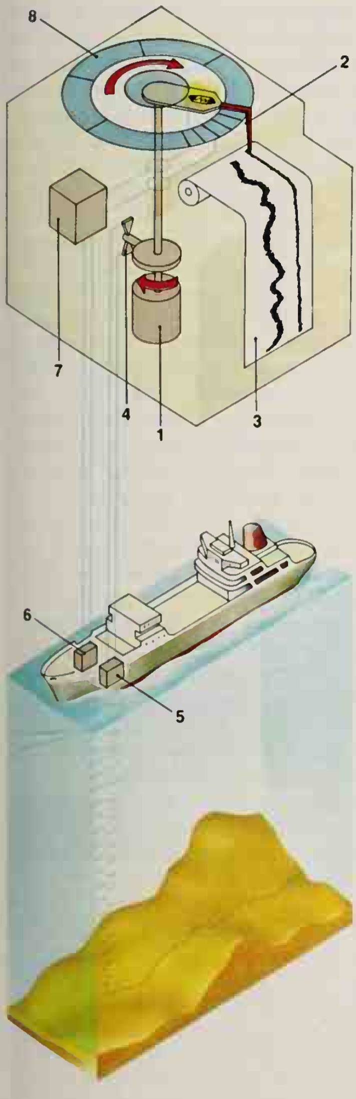
Somoza (family) The Somoza family ruled NICARAGUA with U.S. support from 1933 until 1979. **Anastasio Somoza García**, b. Feb. 1, 1896, d. Sept. 29, 1956, took over command of the U.S.-trained National Guard in 1933, when the U.S. Marines, who had occupied Nicaragua since 1912, left the country. In 1934 he ordered the execution of Gen. Augusto César Sandino, the leader of a popular insurrection. Somoza García served as president from 1937 to 1947 and, after an interim during which he maintained tight control, from 1950 until his assassination, in 1956.

Somoza García was succeeded by his older son, **Luis Somoza Debayle**, b. 1922, d. Apr. 13, 1967. Educated in the United States, Luis was more liberal than his father and implemented limited social and economic reforms. However, even when forced to step down (1963) by a law preventing succession by himself or a close relative, he remained firmly in command. When Luis died his younger brother, Gen. **Anastasio Somoza Debayle**, b. Dec. 5, 1925, d. Sept. 17, 1980, was elected president. Educat-

Gen. Anastasio Somoza Debayle ruled Nicaragua from 1967 until his overthrow in 1979. The Somoza family had dominated the country both politically and economically since the 1930s. He was assassinated in Asunción, Paraguay, where he was living in exile.

ed at the U.S. Military Academy, Anastasio had succeeded his father as head of the National Guard. He was president from 1967 to 1972 and from 1974 until his overthrow by a revolution headed by the left-wing Sandinista National Liberation Front—a guerrilla group named for General Sandino that had become increasingly active during the 1970s. After his overthrow he settled in Paraguay, where he was assassinated.

sonar Sonar (an acronym for *so*und *na*vigation *a*nd *r*anging) is a system for underwater detection and location of objects by acoustical echo. The first sonars, invented during World War I by British, American, and French scientists, were used to locate submarines and icebergs and were called *asdics* (for *a*nti-*s*ubmarine *d*etection *i*nvestigation *c*ommittee) in Britain. *Sonar* is an American term dating from World War II. Most of the advances made in sonar technology since World War II are shrouded in military secrecy. It is known, however, that the system is used to hunt submarines, to control antisubmarine weapons, to direct homing torpedoes, and to locate mines. Civilian sonar systems called echo sounders are used by both commercial and sport fishermen. Marine seismologists employ a sonar that generates sound by means of a small explosion.



Sonar is an underwater sound-ranging system used for locating objects substantial and extensive enough to return an echo. The same technique is used by porpoises when they emit sounds to echolocate schools of fish. A typical sonar device has a motor (1) that drives a recording arm (2) and—through a system of gears, not shown—a recording chart (3). A rotating contact (4) causes a transmitter (5) to emit a sound impulse once every revolution. No further impulse is sent until an echo arrives at the receiver (6) from the seafloor or from some intervening object. The echo is passed through an amplifier (7) and then activates the recording arm; a pen at the tip of the arm marks on the chart the time taken for the impulse to return. This time is given in terms of depth by a calibrated scale (8). A series of such readings is seen at the center of the chart; the steadier line at the right is the echo picked up almost immediately at the surface as the signal is transmitted.

Sonar operates by transmitting regular pulses of sound energy that travel through the water and are reflected by a target; the echo is received, amplified, and then displayed. The time that elapses between transmission and reception indicates the distance from the sonar to its target. The display mechanism transforms the received sound waves into electrical impulses that normally cause a stylus to mark a strip of paper that is moving on rollers. The display has a time base. The ability of a sonar to show resolution (detail) improves as the transmitted pulse is made shorter. If the sound beams are narrowed, the angular resolution (the capability for distinguishing two targets at different angles) improves.

The range and effectiveness of sonar are affected by many factors. The water surface and bottom are natural limits to propagation. Sonar effectiveness may also be affected by the absorption of sound energy by the water, refraction of sound waves by water, variation of the velocity of the sound wave, the presence of acoustic noise, and the presence of turbulence.

sonata Along with the symphony, concerto, and string quartet, the sonata ranks as one of the grandest forms of instrumental music. Among them it can boast the longest history, dating back more than four centuries to the earliest uses of sonata as a musical title. Since the latter part of the 17th century, most sonatas have been divided into two, three, or four movements, and since the late 1700s most have been scored for piano alone, or with one other instrument. Most sonatas have been conceived as nondescriptive music; that is, they have been composed for the sheer pleasure of playing and hearing them, without a specific function or occasion in mind.

The term *sonata* is used in three distinct ways. First, it may mean a complete work, or cycle of movements. Second, it may be the overall, generic term for any instrumental cycle, whatever its scoring, that is primarily abstract rather than functional. In that sense the term applies to all three form types mentioned at the outset—the symphony for full orchestra, the concerto for one or more soloists and orchestra, or the string quartet for two violins, viola, and cello. Finally, *sonata* is used in the term *sonata form* to mean a design found mainly after 1750 in the first movement of a sonata cycle.

Sonata Form. Sonata form is divided into three main sections. (1) An exposition presents in succession two or more ideas, or themes, that contrast in style and often in mood. (2) The development explores the potential meanings of any or all of these ideas by variously dissecting, expanding, combining, or interchanging them. (3) The recapitulation restates the exposition but includes those fuller meanings which the themes now evoke.

When prepared by a slow introduction, capped by a coda, or framed by both, sonata form achieves greater extension. Its three main sections describe a grand A-B-A design. The two A sections, however, differ in their tonal directions and tensions; that is, the exposition creates tension by modulating (moving away) from the home key, whereas the recapitulation relaxes that tension by returning to and remaining in the home key. In between, the development creates further tensions by modulating more continuously and into more remote keys.

Sonata Cycle. Within the sonata cycle, sonata form is identified especially with the first movement and therefore is often called sonata-allegro form, because that movement typically is marked allegro (spirited, fast). The second movement is usually the slowest, anywhere from very slow (adagio) to moderate (andante), and is characteristically lyrical and melodious.

When there are four movements, the third is normally a dancelike piece in triple meter (three beats per measure), especially a minuet at a moderate tempo or a faster scherzo. A-B-A design prevails in this movement, too, with a B section, or trio, that typically provides the lightest movements in the whole cycle. The last movement, or finale, is generally more rapid, lively, and brilliant than the previous movements. Frequently it is a light rondo, alternating a tuneful refrain (A) with various episodes, as in the design A-B-A-C-A-B-A-coda.

Sondheim, Stephen [sahnd'-hym] A highly successful Broadway composer and lyricist, Stephen Sondheim, b. New York City, Mar. 2, 1930, won recognition with his lyrics for *West Side Story* (1957), with music by Leonard Bernstein. Sondheim has subsequently written both lyrics and music for a number of musicals, including *A Funny Thing Happened on the Way to the Forum* (1962), and *A Little Night Music* (1973). The dark, operatic *Sweeney Todd* (1979), the musically complex *Sunday in the Park with George* (1984), and the folk-tale–based *Into the Woods* (1987) attest to Sondheim's role as a major musical innovator.

song Singing is a natural outgrowth of speech rhythm and inflections. In its most elementary definition, a song is a group of words produced as musical tones rather than as ordinary speech and placed within a rhythmic context.

Folk song is the unselfconscious product of nonprofessional musicians reflecting on everyday, often rural, life. Folk songs were originally passed along orally from one singer to another, but urbanized societies now seek to preserve the songs by recording and publishing them (see FOLK MUSIC). Popular songwriting is essentially a commercial enterprise. Since its aim is mass appeal, most popular song features a prominent melody and restricts itself to simple but memorable harmonies and rhythms—although such composers as George Gershwin and Cole Porter have brought American popular song to a peak of sophistication and subtlety.

Art song is the furthest removed from singing's folk roots and from the listener's own experience. Its techniques of composition and performance have evolved along with other forms of classical music. The first substantial collections of composed songs in Western music are PLAINSONG, or Gregorian chant, and the troubadour songs of the 12th and 13th centuries. Plainsong, a flowing, free-rhythmed type of melody, was the principal music of Christian liturgy in the Middle Ages. The MINSTRELS, MINNESINGERS, AND TROUBADOURS of France and Germany were poet-musicians who composed unaccompanied songs in praise of courtly love.

Accompanied song begins in the 14th century, with the ballade, virelay, and rondeau of Guillaume de Machaut and the ballata of Francesco Landini. Named for their verse forms, these songs were typically performed by a singer and two instruments. Early in the 16th century, collections of songs with lute or guitar accompaniment appeared in Germany and Spain, leading to the highly refined English airs (lute songs) of John Dowland and Thomas Morley a century later.

The modern era of art song begins with the deliberately simple, folk-song–inspired German songs of the preromantic period—for example, Mozart's *Das Veilchen*. Franz Schubert so advanced the psychological and pictorial power of song that Oct. 19, 1814, the day the 17-year-old Schubert composed *Gretchen am Spinnrade* to words by the poet Goethe, has been called "the birthday of the German *lied*." The roles of poet and composer have remained separate in modern art song: an exception is Gustav Mahler's *Lieder eines fahrenden Gesellen* (1883), four songs with texts by Mahler himself.

The German lied stimulated new art-song compositions in many other countries. The French art song followed its own course through the romanticism of Gabriel Fauré, the impressionism of Claude Debussy and Maurice Ravel, the witty music-hall style of the 1920s, and a synthesis of all of these by Francis Poulenc. Twentieth-century English song composers such as Ralph Vaughan Williams and Benjamin Britten have drawn on Elizabethan and folk traditions.

In the United States, the romantic influence was strong in the songs of Edward MacDowell and Charles Griffes. In reaction, Charles Ives cultivated iconoclasm and the picturesque. By the mid-20th century, Samuel Barber, Aaron Copland, and Ned Rorem had developed a lean, melodious idiom for the American art song.

Song (Sung) (dynasty) [soong] During the reign of the Song dynasty of China (960–1279), a time of great cultural achievement, occurred the flowering of the Chinese system of bureaucratic centralization and economic regulation initiated under the preceding Tang. The founder of the Song, **Zhao Guangyin** (927–76; r. 960–76), a general whose seizure of the throne ended the series of short reigns known as the Five Dynasties, put the military under civil administration to prevent the militarism that had brought down the Tang. In general, the Song was not militarily powerful; however, the early Song achieved broad geographic control through Zhao's conquests and boasted a large, strong central bureaucracy. Rapid commercial expansion fostered the growth of trade guilds and the use of paper currency. Radical reformer Wang Anshi (1021–86) introduced, over bitter opposition, such regulatory measures as price stabilization, loans to businesspeople and peasants, and the establishment of emergency grain reserves.

A resurgence of cultural activity made the Song one of the high points in Chinese intellectual and artistic history. Perfecting earlier styles, such painters as MI FEI, MA YÜAN, and XIA GUI carried Chinese landscape painting to its highest peak. Porcelain ware, particularly the green celadons, became famous all over the world. Scholarship was stimulated by the invention of movable type, although printing from woodblocks remained primary. There was a great output of poetry; professional storytelling and colloquial drama found favor among the people. A Confucian revival infused with Buddhistic elements was molded in the 12th century by ZHU XI into a philosophical synthesis known as Neo-Confucianism, which served as the new orthodoxy for seven centuries.

In 1127, Jurzhen tribes drove the Song dynasty south of the Chang Jiang. The Southern Song ruled from Hangzhou until 1279, when it was overthrown by the Mongol army that established the Yuan dynasty.

Song Huizong (Sung Hui-tsung) [soong hweydzung] Song Huizong, b. 1082, d. June 4, 1135, was the 8th emperor of the Northern Song dynasty. Perhaps best known as an artist, he is famous for his meticulously rendered bird-and-flower paintings and for his so-called slender-gold calligraphy style. He presided over a new imperial academy of painting outstanding in the history of Chinese art. An avid collector, Huizong acquired more than 6,300 paintings for the imperial gallery. His patronage extended to music, poetry, and the minor arts.

Politically, Huizong's reign (1101–26) proved disastrous. At first he attempted reforms but later increasingly left affairs of state to his minister Cai Jing and other favorites. Corruption and intrigue weakened the government, and nomadic tribes constantly threatened China's borders. An unfortunate alliance with the Jin (Jurzhen) Tatars and their subsequent treachery resulted in the loss of North China. On Jan. 18, 1126, Huizong abdicated in favor of his son, Qinzong. When the capital, Kaifeng, fell (1127) to the Jin, both emperors were captured and taken to Manchuria, where Huizong died.

Song of Myself A poem in free verse that first appeared untitled in *Leaves of Grass* (1855), *Song of Myself* is generally considered Walt WHITMAN's greatest poem. Comprising 1,336 lines and 52 sections, the poem gives expression to the poet's belief that his "self" is identical to all selves on earth. His body achieves union with his soul, and the world becomes alive to all his senses. Perceiving death as merely the separation of the self from one of its identities, Whitman suggests, "If you want me look for me under your bootsoles."

Song of Roland see CHANSONS DE GESTE

Song of Solomon A book in the Old Testament of the Bible, the Song of Solomon, also known as the Song of Songs or the Canticles, is a collection of lyric poetry celebrating human love. The tradition of Solomonic authorship does not stand scrutiny. The milieu of the poetry is heavily northern Israelite and the imagery rural, although the poems may actually have originated among sophisticated urbanites. It is thought that love lyrics from 950–750 BC were collected and supplemented in postexilic times and accepted among religious Jews as an allegory of the relationship of God and Israel. The early Christian church accepted this, with the allegory becoming that of Christ and his church. Other scholars interpret the song as a collection of hymns to true love, sanctified by union.

songbirds Songbirds, with about 4,000 species, comprise nearly half of all birds. Their most basic characteristic is the structure of the syrinx, or vocal organ. Commonly called "oscines," they are represented by about 42 families in the suborder Oscines, order Passeriformes. Songbirds include such forms as the BIRD OF PARADISE, CROW, FINCH, JAY, LARK, ORIOLE, SHRIKE, SWALLOW, WARBLER, and WREN.

Songbirds range in length from 7.5 to 110 cm (3 to 43 in) and in weight from 5 to 1,350 g (up to 3 lb). The syrinx is located at the junction of the trachea and bronchi and includes muscles involved in vocalization, as well as modified supporting rings and membranes and air passages. The mechanisms of the syrinx are poorly understood, but structurally the syrinx of the oscines, which possesses four pairs of intrinsic muscles, is more complex than that found in other passeriform suborders (suboscines).

The name *songbird* implies a high degree of vocal capability, and in most cases the vocalizations are acoustically complex and often attractive to humans, as in the songs of the CANARY and the NIGHTINGALE. Vocalizations of many songbirds, however, such as crows and jays, hardly merit the name "song." Several songbirds do not sing, even poorly. The singing behavior that is so characteristic of many songbirds during breeding season functions in territorial advertising and in attracting a mate. In this way, singing operates in species recognition as a reproductive isolating mechanism. Along with the conspicuous and distinctive plumages worn by many species, especially by males in breeding season, these vocalizations have played a role in the evolution of many species.

For most songbirds, insects are the staple diet. Some, such as the TANAGERS of the family Thraupidae, feed on fruits in addition to insects. Finches and sparrows of various types eat seeds. Several groups have independently evolved specializations for taking nectar from flowers. They often have tubular tongues that apparently act like soda straws. A wide variety of bill types and foraging strategies are used in association with these and other feeding specializations.

Songhai (empire) [sahng'-gy] Songhai (or Songhay) is the name applied to the imperial Muslim state that ruled much of the West African grasslands area from 1464 to 1591. From its capital at Gao, and major trading cities at TIMBUKTU and Jenne—all located along the great bend of the Niger River—merchants and soldiers developed and protected a lucrative trading enterprise that extended both south toward the forests and north across the Sahara Desert. Songhai was governed by gifted leaders, including its founder, Sunni Ali (r. *c.*1464–92), and the illustrious king Askia Muhammed Toure (r. 1493–1528). The Songhai rulers were able to sustain a strong Islamic culture in the towns and trading centers while presiding as "traditional" kings over the mass of the non-Muslim population. Timbuktu in particular achieved fame as a center of Islamic scholarship. The Songhai empire fell after invasion by a Moroccan army. Today descendants of the Songhai live primarily in Mali, Upper Volta, and Niger and number more than 850,000.

sonnet Derived from the Italian *sonetto,* meaning "little song," the sonnet is a poem of 14 iambic pentameter lines. Sonnets have been written in various rhyme schemes, but the most durable pattern has been the Italian, or Petrarchan, sonnet. It consists of an octave (8 lines) rhyming *abbaabba* and a sestet (6 lines) using two or three rhymes in various combinations (see VERSIFICATION). The most famous practitioner of the Italian sonnet was PETRARCH; a variation of the form entered English poetry in the 16th century through translations of his sonnets. Although the original topic of the sonnet was love of a mistress (as in Petrarch), the form has since been used for a variety of subjects.

Sonnets of Shakespeare Originally published in 1609, William SHAKESPEARE'S sonnets are 154 poems that scholars believe were written in the 1590s. Conjecture continues on several points—the sequence of composition, whether the sonnets have a chronological and thematic order, and the identity of the people addressed. Many of the first 126 sonnets were apparently written to a young man, and some of those numbered 125–154 are addressed to a mysterious "dark lady." Shakespeare, or his publisher, dedicated the volume to a "Mr. W. H.," whose identity has never been established.

Unlike the Italian, or Petrarchan, SONNET, Shakespeare's sonnets—also called Elizabethan or English sonnets—consist of three quatrains and a rhyming couplet, with a rhyme scheme of *abab cdcd efef gg* (see VERSIFICATION). They cover a variety of philosophical themes, such as time and death, love, friendship, and the immortality of poetry.

Sonora [soh-noh'-rah] Sonora, a mountainous state in northwestern Mexico on the Gulf of California, borders the United States. It has an area of 182,052 km^2 (70,291 mi^2) and a population of 1,822,247 (1990). It is the country's second largest state in area but the least densely populated. The capital is HERMOSILLO. Sonora has been important for its silver, gold, and lead mining since colonial times. Crops include wheat, corn, cotton, and rice. Home to the YAQUI and Seri Indians, the region was first explored by the Spanish in the 16th century and became a state of independent Mexico in 1830.

Sons of Liberty The Sons of Liberty was a secret American intercolonial organization founded in November 1765 to oppose the STAMP ACT. It was formed by John Lamb and Isaac Sears in New York City. Chapters soon appeared throughout the colonies, mainly in cities and larger towns. Although representing a cross section of society, the Sons of Liberty were mostly tradespeople, laborers, and shopkeepers. Besides transmitting intelligence to other chapters, local members resisted implementation of the Stamp Act by persuasion, pressure, or violence. In some places, notably New York and Connecticut, the group also functioned as a paramilitary association. The organization disbanded after repeal of the Stamp Act in March 1766.

Sontag, Susan [sahn'-tag] An American essayist and novelist, Susan Sontag, b. New York City, Jan. 16, 1933, is best known for her iconoclastic essays on aesthetics in *Against Interpretation* (1966), in which she approaches art through sensory rather than intellectual experience. Aversion to the traditional critical practice of

Susan Sontag, a critic, author, and film director, is best known for the polemical essays contained in Against Interpretation *(1966) and* Styles of Radical Will *(1969). She also edited* A Roland Barthes Reader *(1982), in which her prefatory essay stands among her finest criticism. Many of her own essays are gathered in* A Susan Sontag Reader *(1982).*

extracting moral meanings from art is reflected in her novels *The Benefactor* (1963) and the Kafka-like *Death Kit* (1967). *Styles of Radical Will* (1969) contains essays on philosophy, film, and politics. Sontag has also written and directed two films, *Duet for Cannibals* (1969) and *Brother Carl* (1974). Her later works include *On Photography* (1977), *Illness as Metaphor* (1978), the experimental short stories in *I, Etcetera* (1978), further essays in *Under the Sign of Saturn* (1980), and *AIDS and Its Metaphors* (1988).

Soochow see SUZHOU

Soong (family) [sung] The Soong (Song) family holds a unique place in 20th-century Chinese history. The three Soong sisters were married to key revolutionary leaders: **Soong Ai-ling** (Song Ailing), 1888–1973, to H. H. K'ung (Kong), who served briefly (1938) as president of the Nationalist government; **Soong Ch'ing-ling** (Song Qingling), 1892–1981, to SUN YAT-SEN; and **Soong Mei-ling** (Song Meiling), b. *c.*1897, to CHIANG KAI-SHEK. Their father, **Charles Jones Soong**, d. *c.*1927, a Methodist missionary and Shanghai merchant, was a financial supporter of Sun Yat-sen. Their brother, **T. V. Soong**, 1894–1971, a banker, established the Central Bank of China and served as the Nationalist minister of finance (1925–31, 1932–33) and later as foreign minister (1941–45) and premier (1945–47). Madame Sun Yat-sen broke with the right-wing Nationalists in 1927; from 1949 she served in the government of the People's Republic of China. Madame Chiang Kai-shek, whose U.S. speaking tours and writings brought worldwide celebrity, fled with the Nationalist government to Taiwan in 1949.

Sophists The Greek Sophists (from the Greek *sophos*, "wise") were professional educators and lecturers who first appeared in the 5th century BC. They turned their attention from science and philosophy to more practical studies, principally rhetoric, politics, and law—the skills young Greeks needed to become successful. Part of their educational ideal still survives in the modern notion of "sophistication." They also encouraged some acquaintance with arts and crafts.

The older Sophists tended to be agnostics in religion, relativists in ethics, and power theorists in politics, but they did not go out of their way to shock people with these ideas. PLATO, in his attempts to demonstrate that SOCRATES was not a Sophist, created imaginary conversations portraying the leading figures of this group. These include GORGIAS, the master of rhetoric; PROTAGORAS, expert lawyer; Hippias, a kind of animate encyclopedia who professed to know everything; and Prodicus, one of the first Greek students of language and grammar.

From the outset the Sophists believed that an opposition existed between "nature" (*phusis*) and "custom" or "convention" (*nomos*). They treated legal codes, ethical ideals, and social systems as merely conventional. They argued, for example, that by nature the weak have no rights against the strong and that the gods were invented by rulers to intimidate their subjects.

Sophocles [sahf'-uh-kleez] The career of Sophocles, *c.*497–406 BC, one of the three great tragic dramatists of ancient Greece, spanned the period of greatest political and cultural achievement in Athens. According to tradition, Sophocles wrote 123 plays and won 24 victories in the city's annual dramatic contests. Of these, only 7 tragedies are preserved in full.

Born of a wealthy family, Sophocles enjoyed the friendship of such leading political and intellectual figures as Pericles and Herodotus. He was active in public life, in 443–442 serving as a treasurer concerned with regulating the tribute of the subject allies of Athens, and in 441–440 serving jointly with Pericles as general during the Samian revolt. He may also have served as general during the Peloponnesian War, and in 413–411 he was one of the ten commissioners who governed Athens after the disastrous Sicilian expedition.

Ajax (*c.*465–450?), Sophocles' earliest extant play, dramatizes the uncompromising nobility, but also rigidity, of the old heroic ideal. *Antigone* (442–441), which turns on the heroine's devotion to her dead brother Polyneices, portrays the conflict between a woman's emotional and religious values and the masculine, secular rationalism of King Creon of Thebes. *Oedipus Rex* (*c.*429–425) is one of the most influential plays ever written. Powerful in its conjunction of character and destiny, its relentless recognition of hidden truth, and its paradoxes of human knowledge and ignorance, it provided Aristotle in the *Poetics* with his model tragic plot and Sigmund Freud in *The Interpretation of Dreams* (1900) with a mythic prototype for the Oedipus complex, a central feature of modern psychoanalytic theory.

The Trachinian Women (*c.*430–420) is Sophocles'

Sophocles, often regarded as the finest tragic dramatist of ancient Greece, was also a distinguished statesman and soldier. Aristotle credited Sophocles with several theatrical innovations, including the introduction of a third actor, which greatly increased dramatic complexity.

only surviving play to deal with the violence of sexual passion. *Electra* (*c*.420–410), like the ORESTEIA of Aeschylus, concerns justice and vengeance in the House of Atreus but focuses on the sensitively drawn character of Electra. Its relation to Euripides' *Electra* (*c*.420–413) is still uncertain. *Philoctetes* (409) and *Oedipus at Colonus* (performed posthumously in 401) both deal with exiled, embittered heroes who are ultimately reconciled with society and the gods.

Sophocles' technical innovations made possible the further development of the drama along more realistic lines. According to Aristotle, Sophocles added a third actor, introduced scene painting, and increased the chorus from 12 to 15 members. Aristotle also praises Sophocles for his close integration of the chorus into the action.

In his focus on a single powerful hero, Sophocles originated the form of tragedy that Western literature has most cultivated. His heroes and heroines are towering figures of violent passions, unyielding in their commitment to their ideals, harsh in their judgment of themselves and others. To be a hero in Sophocles is to be the bearer of a destiny that is mysteriously bound up with the divine will, but one that nevertheless must be worked out in the individual's life.

Sophocles' famed "piety" is not synonymous with complacency. His gods, like Apollo in *Oedipus Rex*, are remote and ambiguous, and their justice often seems unclear or even cruel. Unlike the gods of Aeschylus and Euripides, they rarely intervene directly but are present indirectly through oracles and omens. They embody the ultimate, inexorable realities that humans must struggle to understand.

Sophocles' great dramatic achievement was to reinterpret the ancient myths through a fuller development of individual character and to endow surface detail with deeper symbolic significance. Recent scholarship has stressed Sophocles' mythic imagination and the darker side of his celebrated "classic serenity." These strengths amply explain the powerful effect his plays continue to exert over modern audiences.

Sophonisba [soh-fuh-niz'-buh] Sophonisba, d. 203 BC, was the daughter of the Carthaginian general Hasdrubal (d. *c*.202). She married the Numidian Syphax, who then fought for Carthage in the Second PUNIC WAR and was defeated (203 BC) by MASINISSA and the Romans. To avoid capture by the Romans, she took poison, perhaps sent by Masinissa, who had fallen in love with her.

soprano The term *soprano* encompasses all the high voice ranges of women upward from middle C for two octaves or more. The coloratura is the highest, lightest, and most flexible; the dramatic and lyric sopranos are slightly darker and heavier. The mezzo-soprano lies midway between the soprano and contralto ranges, and the soprano voice between the dramatic and lyric is called *spinto*. Composers do not consistently designate the type of soprano required but expect the range and character of the written part to serve as guides for the selection of voices. The voices of young boys also lie in the soprano range.

Sopwith Camel [sahp'-with] Acclaimed as the most successful fighter plane of World War I, the single-seat Camel biplane, with an 8.4-m (28-ft) wingspan and a characteristic short nose, achieved more combat victories (1,294 enemy aircraft downed) than any other individual type of airplane. Most Sopwith Camels were equipped with the 130-hp Clerget rotary engine, but some received the 110-hp le Rhône engine. Twin Vickers machine guns were installed on the coaming in front of the pilot. Other important features of the Camel were its outstanding degree of maneuverability and its ability to carry four 11-kg (25-lb) bombs in a rack beneath the fuselage. On the western front the Camel—of which 5,490 were built—joined squadrons of both the Royal Flying Corps and the Royal Naval Air Service during mid-1917. Home-defense Camels fought zeppelins and Gotha bombers attacking the United Kingdom, and the 2F.1 variant was evolved specifically for use at sea.

The Sopwith F.1 Camel biplane was England's most successful World War I fighter, credited with shooting down 1,294 enemy aircraft. It was highly maneuverable, carried two machine guns, and had a top speed of 196 km/h (122 mph).

Sorbonne see PARIS, UNIVERSITIES OF

Sorel, Georges [sohr-el'] The French social philosopher Georges Sorel, b. Nov. 2, 1847, d. Aug. 30, 1922, is best known for his *Reflections on Violence* (1908; Eng. trans., 1912), which advances his socialist theory of revolutionary SYNDICALISM. Sorel espoused various forms of violent action in order to achieve the ends of social revolution, including the action of a GENERAL STRIKE—which, according to syndicalist ideas, could occur if an inert working class were to be galvanized into mass, unanimous action by a militant minority. Sorel considered creative "violence" to be the proletariat's heroic means of opposing and overturning the existing bourgeois "force."

sorghum [sohr'-guhm] Sorghum, a member of the grass family, is of great agricultural importance in dry and arid lands. Its hundreds of varieties and many hybrids are

The sorghum Sorghum bicolor *is an annual, coarse grass that is grown worldwide as a commercial crop and is used as livestock feed. Other sorghum species produce a sweet, edible syrup.*

generally classified into four groups: the grain sorghums, used mainly for stock and poultry feed; the grass sorghums, used for hay and pasture; the sweet sorghums, which provide molasses and syrup as well as hay and silage; and broomcorn, whose fibers are used to make brooms. All sorghums have extensive branching root systems that provide exceptionally good resistance to drought and can withstand hotter climates than can other grain crops.

Sorghum has been a major crop in Africa since prehistoric times, although only one African country, Sudan, is a significant producer. The United States grows the largest crop, followed by India, China, and Mexico.

Methods of cultivating, harvesting, and handling sorghum are similar to those used for other cereal crops. A self-pollinated annual planted in the spring, sorghum can reach heights of 5 m (16 ft). Seed color ranges from white to dark reddish brown.

In industrial countries sorghum is almost entirely a feed grain. It is ground and used with other grains for formula feeds. The fermentation industries use sorghum for brewing, distilling, and making industrial alcohol. Industrial uses of sorghum involve some wet and dry milling operations for starch and by-products. Sorghum makes excellent pasture for livestock, as well as high-quality silage. For human food, the kernels can be parched, popped, or whole-boiled. Ground or cracked grain is made into flat, unleavened bread, porridge, or paste.

Sorokin, Pitirim A. [soh-roh'-kin, pit-ir-eem'] Pitirim Alexandrovitch Sorokin, b. Russia, Jan. 21 (N.S.), 1889, d. Feb. 10, 1968, was a major 20th-century sociologist and social philosopher. He became the University of Saint Petersburg's first professor of sociology in 1919, and after his expulsion from Russia emigrated to the United States, where in 1930 he founded Harvard University's sociology department.

Especially interested in social change, Sorokin distinguished three basic types of sociocultural systems: the sensate, in which the perception of reality is oriented toward what can be perceived with the senses; the ideational, which emphasizes faith in supersensory means of knowledge; and the idealistic, which tries to balance the first two. Sorokin's integralist philosophy posits reality as a combination of all three perspectives. His works include *Social Mobility* (1927), *Social and Cultural Dynamics* (1937–41), and *Society, Culture, and Personality* (1947).

sororities see FRATERNITIES AND SORORITIES

sorrel [sohr'-ul] Sorrel is the name used for various edible plants that have a sour juice. Most belong to the genus *Rumex* of the buckwheat family. Several *Rumex* species are perennials whose fleshy, spearhead-shaped leaves are used in soups and salads, such as *R. patientia*, also called spinach-dock; *R. acetosa*, known as garden sorrel; and *R. scutatus*, called French sorrel. Sorrel is especially popular in Europe; some U.S. cultivation occurs in California and the southern states. Sheep sorrel, *R. acetosella*, a widespread weed, was introduced into the United States from Europe. Wood sorrel is the name of several plants in the genus *Oxalis*.

Sotatsu [soh'-taht-soo] The Japanese painter Tawaraya Sotatsu (1576–1643) is credited with founding the school of decorative ink painting known as *Rimpa*. His highly influential style combined classical motifs with fluid brushstrokes and flat masses of color. In collaboration (*c.*1606–20) with the artist KOETSU he produced beautifully decorated literary texts as well as scrolls in which Koetsu wrote classic poetry over Sotatsu's designs of birds, flowers, or deer rendered in gold and silver. After 1620, Sotatsu worked independently, transforming motifs taken from illustrated narratives of the 12th and 13th centuries into decorative designs on gold-leafed screens and sliding doors.

Sotho [soh'-toh] The Sotho (Basotho) are a people who now live in the constitutional monarchy of Lesotho, the former British Protectorate of Basutoland; they numbered about 1.5 million in the late 1980s. The term *Sotho* is also frequently used to refer to that group of African peoples inhabiting Lesotho, Botswana, and parts of South Africa who speak a subdivision of BANTU languages known as SeSotho.

Sotho political history is complex, involving battles with NGUNI tribes as well as conflicts with the British and the Boers (see AFRIKANERS). The integrity of the Basotho nation, in spite of a period of British colonial rule, was inspired by the remarkable statesmanship of MOSHESHWE in his negotiations with black and white foreigners during the 19th century. His greatest achievement, however, was his success in bringing rival Sotho tribes under his central authority.

After achieving independence from Britain in 1966, the landlocked nation of Lesotho was obliged to continue strong economic ties with South Africa for trading purposes. South Africa is thought to employ about 40% of Lesotho's able-bodied men and women as migrant laborers; in 1983, 102,000 Sotho miners were reportedly working in South Africa. Political relations between the two countries are strained, notably regarding South Africa's policies of APARTHEID.

soul *Soul* is a term rarely used with precise definition in philosophy, religion, or common life. It is generally regarded as descriptive of an entity related to but distinguishable from the body—the spiritual part of human beings that animates their physical existence and survives death.

Primitive religions tend to associate the soul with the vital force in humans and often identify it with particular parts or functions of the body (the heart or kidneys, the breath or pulse). Other religions show traces of such animistic ideas. In Hinduism, the Atman (originally meaning "breath") is the individual factor that is indestructible and that after death is reborn in another existence. Atman, however, is identified with Brahman, the Source of all things to which the soul ultimately returns when it ceases to have a separate existence. (Buddhism, on the other hand, repudiates the notion of Atman, positing the theory of Anatta, nonself.) Early Jewish thought did not conceive the soul as existing apart from the body except in the shadowy realm of departed spirits (*Sheol*). Greek and especially Platonic thought divided humans into two parts: body and soul. The soul, often referred to as the *psyche*, was considered both preexistent and immortal.

The early Christian church lived under the influence of Greek ideas about the body and soul, although biblical teachings about RESURRECTION were superimposed on them. Throughout the history of the Christian church, there has been no clearly defined and universally accepted metaphysical conception of the soul. Nevertheless, Christian theology and worship have adhered firmly to the conviction of personal survival after death.

soul music A successful popular-music style, soul music is derived from black GOSPEL MUSIC, with its highly decorated, emotional singing style, fervent backup choruses, and rhythmic instrumental backing. In the late 1940s and early 1950s, BLUES singers such as Bobby Bland, and vocal groups like the Ravens, used a gospel-tinged sound. Church singers began to record popular music in the 1950s, among them The Dominoes, led by Clyde McPhatter, and Sam Cooke, who was well known as a gospel singer before he "crossed over." The most important names in 1950s soul music, however, were James BROWN, whose 1956 "Please, Please, Please" had all the raw urgency of black preaching, and Ray CHARLES, whose 1959 "What'd I Say?" took the new sound to a wide audience.

The soul style was greatly popularized in the 1960s by the success of the MOTOWN group of record labels, and by Aretha FRANKLIN, the daughter of a well-known Detroit preacher, many of whose recordings became national hits. Other important soul singers of the 1960s included Otis REDDING and Wilson Pickett, who were practitioners of the so-called Memphis sound. Throughout the 1960s the soul style was smoothed and softened to make it more acceptable to mass audiences. This tendency continued during the 1970s and '80s, when "soul music" became an accepted element of American popular music, growing increasingly sophisticated but retaining its basic church elements: decoration, drive, and verve.

Aretha Franklin, known as Lady Soul, was the leading soul singer of the 1960s and early '70s. Trained as a gospel singer, Franklin expanded her powerful, emotional style to include elements of popular music and rhythm and blues. "Respect," "Chain of Fools," and "Natural Woman," all released in 1967, are among her most successful records.

Soult, Nicolas Jean de Dieu [soolt] Nicolas Jean de Dieu Soult, b. Mar. 29, 1769, d. Nov. 26, 1851, was a French soldier and politician. He served in the FRENCH REVOLUTIONARY WARS, rising to the rank of general after the Battle of Fleurus (1794). Promoted (1804) to marshal by Napoleon I, he further distinguished himself at Ulm and Austerlitz (1805) and at Jena (1806). He commanded ably in the Peninsular War (1808–14; see NAPOLEONIC WARS) but was defeated by the future duke of Wellington. Although Soult turned royalist during the First Restoration (1814), he rejoined Napoleon as chief of staff at Waterloo. Returning (1819) from exile, he served in three ministries (1832–34, 1839–40, 1840–47) but again became a republican after the Revolutions of 1848.

sound and acoustics The science, engineering, and art of the generation, propagation, and reception of sound waves constitute the subject of acoustics. Although the Greek origin of the term refers to sounds that can be heard, the subject of acoustics ranges from the very slow, subsonic vibrations of the Earth and its atmosphere to the very rapid ultrasonic vibrations that lie far above the range of human hearing. The impact of the study of acoustics is extremely widespread. Acoustics is important, for example, in the fields of speech and hearing, the production of music, the design of theaters, the control of unwanted vibrations and noise in the environment, and medical diagnosis and therapy.

Propagation

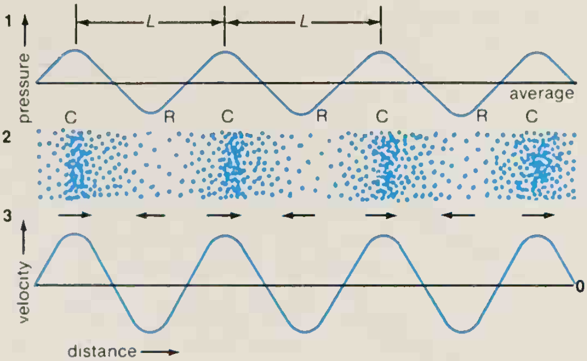
Sound needs an elastic medium—solid, liquid, or gas—through which to propagate. Unlike light and other electromagnetic waves, sound cannot exist in a vacuum. When a small region of the elastic medium is compressed, it exerts a tug on its neighboring regions, and they in turn pull on their neighbors. If the region is expanded, it will push on its neighbors, and that push will also propagate through the medium. If the compressions and expansions are alternated in a regular way, regions of alternating high and low density will propagate throughout the medium; the result is a sound wave. As the wave goes by, each particle in the medium oscillates. Neighboring particles do not oscillate in unison, but are slightly out of phase, alternately moving closer together and farther apart, thus creating the density changes. Sound waves are longitudinal, because the motion of the particles is parallel to the direction of propagation of the wave.

Characteristics of Sound Waves

The pitch of the sound is determined by its frequency—the rate at which the vibrations occur. The units of frequency are called Hertz (Hz); 1 Hz is equal to 1 vibration per second. The human ear is sensitive to frequencies between about 20 Hz and 20,000 Hz. Frequencies lower than 20 Hz are called infrasonic; those higher than 20,000 Hz are called ultrasonic.

The magnitude of the changes associated with a sound wave are remarkably small. For example, a tone of middle C (261 Hz) played in air as loudly as the ear can tolerate results in density changes about 0.02% above and below the density of quiet air; the maximum displacement of air molecules is less than one-tenth of a millimeter (0.004 in).

The wavelength of sound is the distance between two adjacent compressions. For a tone of middle C in air, the wavelength is about 1.2 m (4 ft); for an ultrasonic wave with a frequency of 75,000 Hz in water, the wavelength is 2 cm (0.9 in). The frequency, the wavelength, and the speed of sound have this relationship: speed equals frequency times wavelength.



The transmission of sound through air involves alternate regions (2) *of increased* (C) *and decreased* (R) *pressure. At increasing distances from a source of sound with a wavelength* L, *the changing pressures and velocities of air molecules moving back and forth* (arrows) *within these regions can be represented mathematically by sine curves* (1, 3).

Speed of Sound. The speed of sound is characteristic only of the medium through which it propagates and does not depend on the frequency of the sound wave. The fact that the speed is independent of the frequency is clear to anyone who listens to a band concert from a long distance. The sounds from all the instruments, from the bass drum to the piccolo, arrive at the same time.

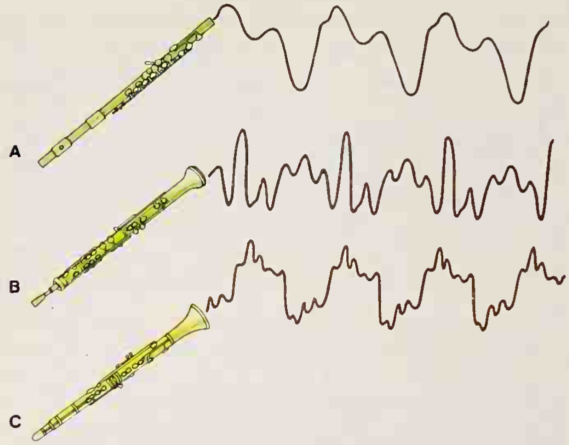
The properties of the medium that determine the sound speed are its compressibility and density. The more difficult it is to change the volume of the medium by squeezing it, the greater the sound velocity; the greater the density, the slower the velocity. Although air has a low density, the speed is, in fact, quite small because air is so easily compressed. Solids, on the other hand, are generally difficult to compress and thus have high sound speeds.

TABLE 1: SPEED OF SOUND IN SELECTED MEDIA

Medium	*Sound Velocity* *m/sec*	 *ft/sec*
Air (20° C)	343	1,125
Water	1,498	4,915
Seawater	1,531	5,023
Lucite plastic	2,680	8,793
Steel	5,060	16,600
Aluminum	5,100	16,700
Pyrex glass	5,640	18,500

Wave Properties of Sound. DIFFRACTION is the bending of waves around obstacles. This book can serve as a barrier to light but not to sound. Both light and sound are waves and are diffracted around the barrier, but the light wavelength is so small that the bending is not noticeable. The sound wavelength, on the other hand, is larger than the size of the barrier; therefore there is very little acoustic shadow.

REFRACTION is the bending of a wave when it goes from a region of one propagation velocity to that of another. The wave bends toward the low-velocity region. Optical



Complicated waveshapes are obtained for the sounds produced by the periodic vibrations of a column of air in a flute (A), *an oboe* (B), *and a clarinet* (C). *The waveforms are distinctive for each instrument and depend on the relative strengths of a series of different sound frequencies generated simultaneously within the vibrating air column.*

lenses are an example of the refraction of light waves. Refraction of sound waves is not something noticeable in everyday experience, but it is important for the study of sound propagation in the ocean. The sound velocity is not uniform throughout the ocean; with increasing depth, the pressure increases and the temperature decreases, and both of these affect the sound velocity. The resultant velocity profiles indicate how a sound wave bends as it propagates through the ocean. Shadow zones (regions that the sound from a particular source cannot reach) and sound channels (layers in which the sound is confined) are commonly found.

REFLECTION of sound is easily observed in any enclosed space. In fact, reflections are so prevalent that in order to study the behavior of audio equipment or of people in their absence, it is necessary to use a specially designed room with 100 percent sound-absorbing walls called an anechoic chamber. The eerie feeling experienced by an individual in such a chamber is ample evidence of the ubiquity of acoustic reflections. On the other hand, the acoustic design of a room for clarity and brightness of spoken or musical sounds must strike a proper balance of reflections and absorption. Reflections are needed to provide a full, diffuse, and uniform sound, but absorption must limit the reverberations to avoid confusion. This balance is characterized by the reverberation time, which for large concert halls is between one and two seconds.

Sources of Sound

Any vibrating object, such as a taut string, a solid plate, or a column of air, is a source of sound. In addition, air rushing past an obstacle fast enough to cause turbulence generates sound waves; an example of this is a whistle. A drum or cymbal is an example of a vibrating plate directly generating sound. In a flute or an organ pipe, rushing air sets the column of air in the tube in motion; the vibration of the air at the end of the tube radiates into the atmosphere. In brass and reed instruments and in the human voice, a vibrating plate (lips and reed, and vocal cords, respectively) sets an air column into vibration. In a piano, violin, or guitar some sound is radiated directly by the vibrating strings, but it is augmented by the sounding board, which is a vibrating plate.

The field of ULTRASONICS was made accessible by the discovery (1880) by Jacques and Pierre Curie of the phenomenon of PIEZOELECTRICITY. Certain crystals, such as quartz, will expand and contract slightly when they are placed in an alternating electric field. Furthermore, their response is rapid; they can be driven at microwave frequencies—as high as a billion vibrations per second. The reverse effect also occurs (and, in fact, is the effect discovered by the Curies); that is, when squeezed, for example, by a sound wave, a piezoelectric crystal creates an electric potential (voltage). Piezoelectric crystals can therefore be used as both receivers and sources of sound waves, from audible to ultrasonic frequencies.

Receivers of Sound

The most important, and technically the most impressive, of all sound receivers is the ear. The ear is capable of detecting sound for which the fluctuations of density of the air are less than one ten-millionth of 1 percent. This figure corresponds to a particle displacement of less than

The frequency range of sounds that can be heard by human ears (1) *extends from about 20 to 20,000 Hz. Bats* (2), *porpoises* (3), *and grasshoppers* (4) *can generate ultrasonic frequencies to about 100,000 Hz. Birds* (5) *and dogs* (6) *produce much lower frequency sounds, all within the range of human hearing. Musical instruments, such as violins* (7), *saxophones* (8), *and harps* (9), *produce a range both of fundamental frequencies* (solid lines) *and of overtones* (dashed lines) *that give the different instruments their distinctive tonal qualities.*

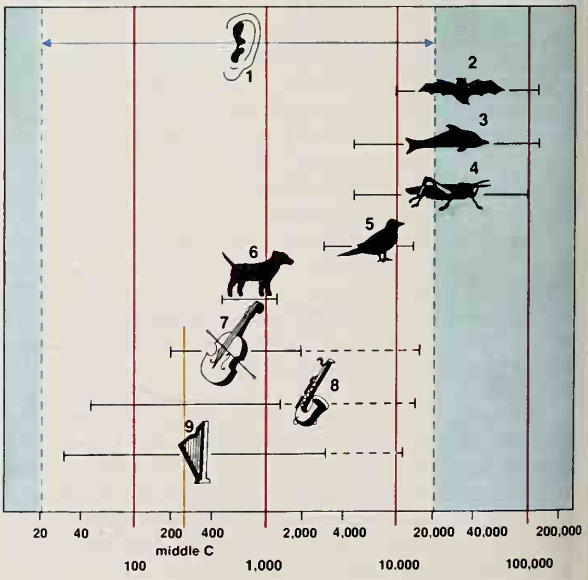


TABLE 2: RELATIVE SOUND LEVELS

Decibels (dB)	*Acoustic Condition*
0	Threshold of hearing
30	Bedroom at night
60	Conversation at one meter
90	Subway train
110	Rock band
140	Threshold of pain
200	Saturn rocket at close range

one atomic diameter. Because the range of acoustic amplitudes that the ear can detect is so large, it has been convenient to define a compressed scale to describe acoustic intensities. In this decibel scale a 10-decibel (dB) difference between two sounds is perceived as a loudness difference of a factor of two.

Regular exposure to sounds of about 90 dB will eventually cause hearing loss, and sounds of 130 dB can cause immediate and permanent hearing loss.

A MICROPHONE is a device that detects the existence of a sound wave and converts the acoustic signal into an electric signal. The electric signal can then be transmitted over large distances, amplified and reemitted, or stored (see SOUND RECORDING AND REPRODUCTION). A simple microphone, such as that used in a telephone receiver, works on the principle that a lump of carbon granules changes its electrical resistance when it is squeezed.

See **also:** DOPPLER EFFECT; MACH NUMBER; WAVES AND WAVE MOTION.

sound barrier An airplane or any vehicle is said to be crossing the sound barrier when its speed exceeds the speed of sound (see MACH NUMBER). Many attempts were made by normal aircraft in the 1940s to break the sound barrier, but they caused the planes to disintegrate because the transition from subsonic to supersonic speeds causes strong nose-heavy changes of trim and sets up structural vibrations that can tear a plane apart. The sound barrier was finally breached on Oct. 14, 1947, by U.S. Air Force captain Charles E. YEAGER in a Bell X-1 research plane. Proper airplane design has since made supersonic flight routine. Design improvements include streamlining, adjustable stabilizers, adjustable incidence tailplanes, and hydraulic-ram positioners for control surfaces.

Sound and the Fury, The A four-part novel by William FAULKNER, *The Sound and the Fury* (1929) dramatizes the disintegration of the Compson family from four points of view. The first section is told from the viewpoint of a 33-year-old idiot, the second by a neurotic on the day of his suicide, the third by a paranoid on the day that his worst fantasies become real, and the fourth by the omniscient author. This STREAM OF CONSCIOUSNESS novel explores past and present to reveal the lovelessness of the Compson brothers. The title is from Shakespeare's metaphorical description of life in *Macbeth* (act 5, scene 3)—"a tale/Told by an idiot, full of sound and fury,/Signifying nothing."

sound recording and reproduction Sound recording involves the mechanical or electronic detection of sounds and their preservation in a storage medium—usually a disc, tape, or film. In reproduction, or "playback," the encoded information is recovered from the storage medium, amplified, and fed to loudspeakers or headphones that re-create a facsimile of the original sound.

In modern recording, sound-pressure waves in the air are detected by one or more MICROPHONES that translate the sound waves into electrical signals. Signals from microphones may be combined in a "mixer" to produce a finished recording. The signals are transformed into sound during playback.

Equipment intended to reproduce music is rated according to the accuracy, or fidelity, of its reproduction. Thus "high fidelity" systems are those which faithfully reproduce the original sound of music, authentically re-creating its full frequency range, dynamic range, and timbre (tone quality).

Sound recordings and reproduction systems are characterized by the number of "channels" of sound that are provided: one (monophonic), two (stereophonic), or more (for "surround" or "quadraphonic" sound).

Recording Classifications

Storage Media. Sound recordings are classified into four general categories according to the technology employed to store the audio signal.

Mechanical Recording. This technology is the basis of all phonograph records. The audio signal is represented by an undulating groove in the surface of a cylinder or disc. For playback, the record spins on a turntable while a lightweight "stylus" traces the pattern of wiggles in the groove.

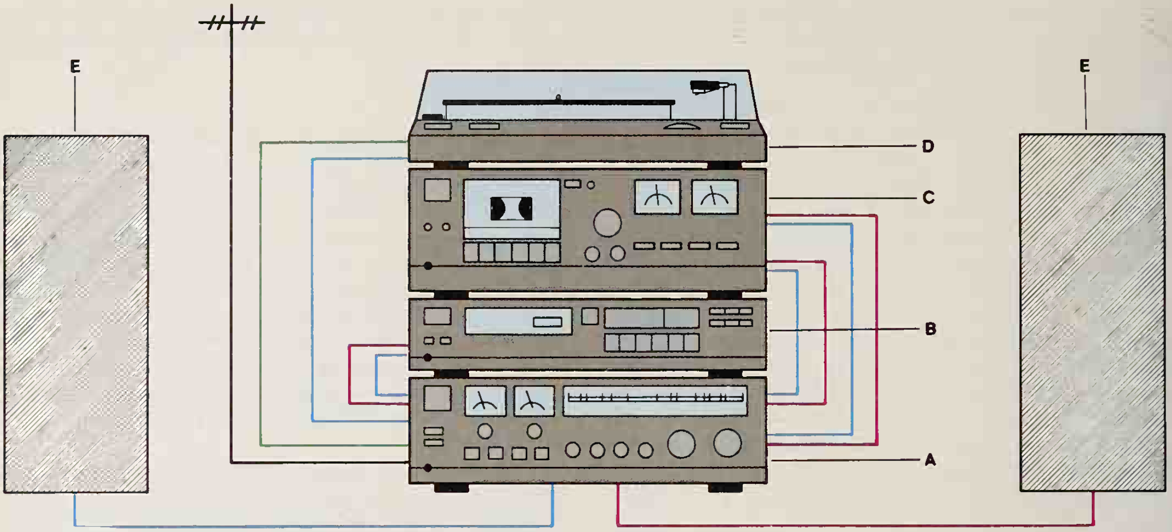
Magnetic Recording. The basis of all tape recording (both audio and video), magnetic techniques are also used for the sound tracks of some 70-mm motion-picture films. In all cases, a plastic tape or film carries a thin coating of magnetic material, usually iron oxide, on which a varying magnetic pattern is imposed during recording.

Optical Film. This technology is used for the sound tracks of all but a few motion-picture films. During recording a "light-valve" varies the amount of light passing through a magnetic field to reach the sensitized film. In playback the developed film transmits a varying amount of light to a photocell, thus re-creating the electrical signal.

Optical Disc. This is the basis of the compact disc (CD) and the VIDEODISC. The signal is represented by a pattern of microscopic pits along a reflective spiral track in the disc. In playback, the pattern is "read" by a small laser and photocell.

Signal Format. Sound recordings are also classified according to the form of the signal recorded in the storage medium.

Analog. All sound is characterized by a pattern of rapidly varying air pressure. In analog recording, that pattern



The basic instruments in a stereo system—those which largely determine the sound quality and sound levels of the entire assemblage—are the receiver (A) *and the speakers* (E). *The receiver combines the functions of power amplifier, preamp, and tuner. It receives FM and AM radio broadcasts and projects received sound through the right and left speakers. The CD player* (B), *tape deck* (C), *and turntable* (D) *are wired to the receiver via right and left sound channels, and operate through the receiver's controls, which include adjustments for tone (bass and treble), volume, and intensity. Two sets of wires (for recording and playing) connect the tape deck and receiver. The green wire grounds the turntable.*

is imposed directly upon the storage medium.

Frequency Modulation (FM). Used for recording the sound and picture in videodiscs and "HiFi" video cassettes, FM is also used in RADIO AND TELEVISION BROADCASTING. The sound-wave pattern is represented by variations in the frequency of a "carrier" signal.

Digital. Digital encoding is the fundamental data-processing method for most present-day computers and for a range of sampling and recording techniques in other fields (see DIGITAL TECHNOLOGY). In sound recording, the sound is represented indirectly by a "binary" (two-state) code in which the recorded signal alternates between "on" and "off" states.

The Phonograph Record

The PHONOGRAPH record was the first successful medium for capturing, preserving, and reproducing sound. It remained the most popular recording medium for nearly a century.

Early History. Practical methods of recording sound waves on the surface of a disc or cylinder and playing them back were described in 1877 by Charles Cros in France and by Thomas EDISON in the United States. Edison turned his idea into a practical working model, and he is credited as the real inventor of the phonograph.

In Edison's phonograph a thin sheet of tinfoil was wrapped tightly around a pregrooved metal cylinder, which was turned slowly by hand. Sound waves caused a thin diaphragm to vibrate, and a blunt needle affixed to the diaphragm inscribed these vibrations as indentations in the foil. The same apparatus played back the recording.

During the 1880s, as the result of experiments sponsored by telephone inventor Alexander Graham Bell, the fidelity of Edison's phonograph was improved by replacing the foil with a layer of wax in which the vibrating stylus could engrave grooves of varying depth. Edison added an electric motor to turn the cylinder at uniform speed, and he conceived a method of producing several copies of a recording by metal-plating the cylinder to create a mold.

In 1888 a German immigrant named Emile BERLINER demonstrated a working "gramophone" in which sound waves were engraved in a spiral groove on the surface of a flat disc, with the stylus vibrating from side-to-side rather than up-and-down. During the following decade Berliner devised a method of mass-producing recorded discs at low cost from metal molds. He also began to manufacture disc players driven by spring-wound motors. His Victor Talking Machine Company, formed in 1901, quickly attracted both performers and the public to the disc format.

Cylinders provided slightly better sound, and Edison continued to produce them until the 1920s, but by 1910 the disc had become the dominant format, mainly because thousands of discs could be molded from just one "master," permitting them to be sold at a lower price than cylinders.

The acoustic phonograph rapidly gained worldwide popularity, though it suffered from two basic limitations. First, since the engraving stylus was moved only by sound vibration, it recorded loud sounds best. Second, in playback, the acoustic output of the system depended on the mechanical power generated by the groove walls pushing the stylus back and forth. It reproduced the human voice remarkably well but could not generate the full volume or tonal range of orchestral sound. The 1912 invention of the "Audion" vacuum-tube amplifier by Lee De Forest, however, inspired efforts to develop electrically amplified phonographs.

The Electrical Era. Amplified recording and playback systems were developed at Bell Telephone Laboratories, the technology was licensed to other companies, and the first electrical recordings—using the microphone, developed from Alexander Graham Bell's telephone transmitter—were issued in 1925. The main advantages of electrical recording were practical. Soft sounds could be recorded, since the microphone's output was amplified to drive an electromagnetic cutting stylus. In playback a small stylus assembly could be used, since its force no longer generated the sound directly; and with sufficient amplification the reproduced sound could fill a large room such as a motion-picture theater.

Record manufacturing declined sharply during the 1930s because the advent of nationwide radio broadcasting promised consumers an endless supply of entertainment at no cost. For over a decade nearly all progress in sound reproduction was financed by the motion-picture industry and by independent laboratories.

The LP. The playing time of the 12-inch (30.5-cm) record remained below 5 minutes from 1900 until 1948, when a team of CBS engineers headed by Peter Goldmark and William Bachman unveiled the microgroove "LP" (long-play) record. A playing time of 20 minutes per side was achieved by slowing the turntable speed from 78 to 33 revolutions per minute (rpm) and by employing narrow, closely spaced grooves. The malleability and low noise of vinyl, which is a congealed liquid rather than a brittle solid, facilitated the use of 0.003-inch (0.0076-cm) grooves in which sound waves are represented by microscopically small wiggles. (Vinyl had replaced shellac, which could not be obtained during World War II.)

The development of the new LP record included the design of low-mass tonearms employing a tracking force of less than 0.5 oz (14 g), reduced to 1 gram by the 1980s.

In 1949, RCA introduced a second microgroove format, a 7-inch (17.8-cm), 45-rpm disc. This became the standard format for "singles," while the 12-inch LP held song albums and longer compositions. For the next decade, most phonographs operated at all three speeds: 78, 45, and 33 rpm.

The introduction of the LP disc was accompanied by two major changes in the character of sound recordings: full frequency-range recording (leading to high-fidelity sound) and mastering on tape (leading to stereo sound).

Full Frequency-Range Recording. Postwar records faithfully reproduced the entire range of frequencies audible to the human ear, from 30 to 15,000 cycles per second. This was accomplished by "equalization," using amplifier circuits to strengthen high frequencies in recording and low frequencies in playback, so that all frequencies were reproduced equally well. The combination of full-range recording with the quiet vinyl disc launched the "high fidelity" era, in which virtually any sound could be reproduced accurately in the living room.

Mastering on Tape. Prior to 1950, all recordings were cut directly on a master disc. If a wrong note was played, the performance had to be repeated while the master disc was recut from the beginning. With the introduction of the magnetic tape recorder, the art of recording gained new freedom. Tapes are easily spliced, so mistakes can be edited out. The various parts of a performance can be recorded separately and combined to produce a finished tape. Because tape machines are portable, recordings can be made anywhere.

To make LP records, the master tape is played in a disc-cutting studio. The tape's signal is amplified to drive electromagnetic coils attached to a sharp-edged cutting stylus, which cuts a groove in a disc coated with acetate or soft copper. The resulting master disc is electroplated, forming a "metal master" that contains a perfect negative impression of the original disc, with raised ridges instead of grooves. This plating can be used to stamp out finished records. For quantity production the negative is replated to produce a positive mold called a "mother," which is repeatedly plated to produce negative stampers. Stampers representing the two sides of a record are mounted in the upper and lower jaws of a press, a "biscuit" of vinyl is placed between them, and the press is closed for about 20 seconds. After the molded disc cools it is removed, excess vinyl around the edges is trimmed off, the center-hole is punched, and the record is packaged.

The high-fidelity movement revived interest in stereophonic sound, the use of two recorded channels to enhance the realism of reproduced sound by providing the directional and spatial impressions that one is able to hear in live performances. In 1957 the industry adopted the present system of "compatible" single-groove stereo, in which the left and right channels of sound are represented by diagonal waves cut into the two sides of a groove. Side-to-side vibration of the stylus corresponds to monophonic sound, while up-and-down motion produces the spatial impression of stereo.

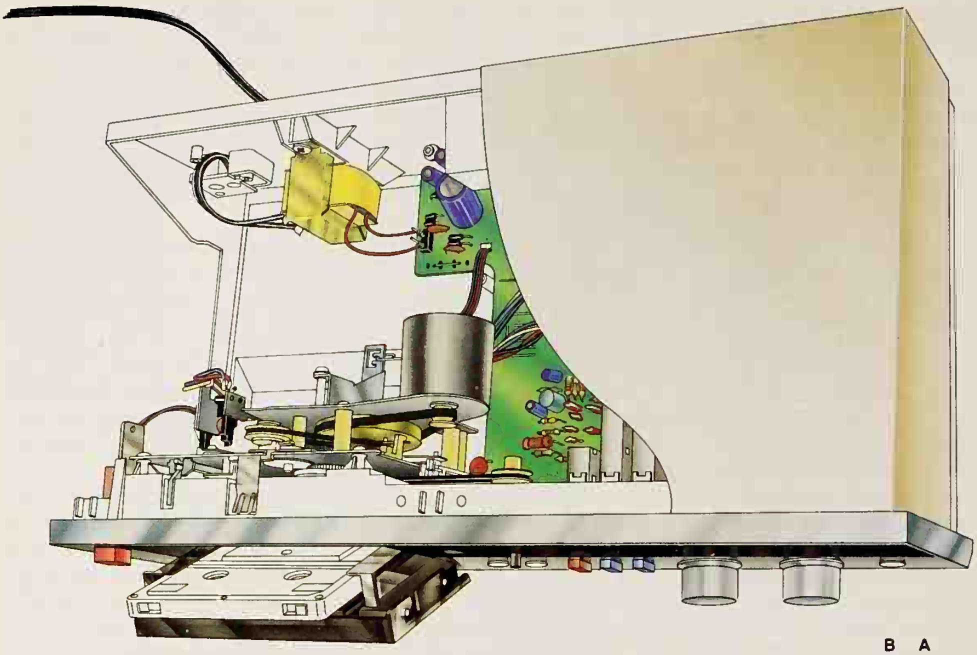
In stereo playback each ear hears sounds from both loudspeakers. To compensate for this blending of the two channels, recording engineers often use exaggerated microphone spacing (much wider than the width of the head), or microphones having a more sharply directional pickup pattern than the ears. When stereo recordings are heard through headphones the result is a wraparound sound that often seems to envelop the listener.

To provide a more convincing aural impression through loudspeakers the industry produced quadraphonic (four-channel) recordings and equipment during the early 1970s, but this technique was not successful commercially.

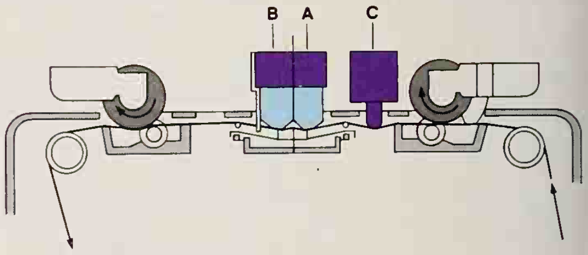
In the late 1970s recording engineers began to use digital tape recorders, improving the clarity of the resulting records. During the 1980s, as listeners turned to the cassette tape and the all-digital compact disc, LP sales declined sharply.

Magnetic Tape Recording

In recent decades magnetic recording has become the most popular of all recording technologies, mainly because of the ease with which magnetic signals can be recorded, edited, copied, erased, or rerecorded. Magnetic



(Above) *A complex piece of equipment, the tape cassette deck includes mechanisms for driving the tape at a steady speed (the motor, gears, and belts in the cutaway portion of the box); controls for producing a bias signal that matches the metallic makeup of tape's particles; recording-level controls and readouts that indicate those levels; other controls to regulate noise reduction; and controls for recording, playback, tape rewind and fast-forward, and a cassette-eject button. Tape movement past the deck's heads is illustrated and described at right.*



(Below) *As recording tape moves across the bottom of the cassette, it contacts the devices in the tape deck that help guide it (the 2 pinch-rollers indicated by curved arrows), and the heads that record, erase, or play back sound. When recording, sound in the form of electric signals generates a magnetic field through a wire coil in the record head* (A), *and metal particles on the tape are magnetized in a pattern analogous to the sound signals. The playback head* (B) *reads the pattern and transforms it back into electric signals. The erase head* (C) *rearranges the particles into a random, unreadable pattern.*

recording is used in audio tapes, videotapes, and computer disks (see TAPE RECORDING).

Magnetic recording is based on electromagnetism. It serves as the basis of recording (conversion of an electrical signal to a magnetic pattern) and playback (conversion of the magnetic pattern back to an electrical signal).

Early Development. The first practical magnetic recorder was patented in 1898 by the Danish inventor Valdemar Poulsen. The device, called the Telegraphone, recorded on a long, thin steel wire. During the 1920s and 1930s some experimental recorders employed a ½-inch-wide (1.27-cm) steel tape instead of a wire, but a reel of this tape was heavy and costly.

In 1928 a German patent was issued for a lightweight paper tape coated with iron powder. AEG Telefunken developed a tape recorder called the Magnetophon, and BASF, a German chemical firm, substituted cellulose acetate film for the breakable paper tape and developed a safe process for making tiny particles of iron oxide.

In 1939, while experimenting with Magnetophons at the German radio network, engineer Walter Weber discovered that adding an ultrasonic tone to the signal during recording yielded much-better-sounding tapes. This "AC bias" was the key to high-fidelity magnetic recording.

After World War II, Magnetophon-like recorders were produced by the Ampex Corp. in California. The Ampex machines, recording on ¼-inch-wide (0.64-cm) tape moving at 30 inches (76.2 cm) per second, were soon adopted throughout the recording and broadcast fields.

With the help of better tapes and equalization circuits, which adjust amplification for accurate sound at all frequencies, tape speeds have repeatedly been halved—to 15, 7½, 3¾, and finally 1⅞ inches (38, 19, 9.5, and 4.76 cm) per second for cassettes—while the development of smaller magnetic heads has allowed several parallel tracks to be recorded on each tape.

Modern Tape Formats. In a tape recorder the tape is spooled off a supply reel, threaded past the recording-playback heads, and wound on a takeup reel. During the 1950s and 1960s many attempts were made to enclose reels and tape in a self-threading package to eliminate the inconvenience of tape handling. By far the most successful design was the "compact cassette," a small plastic box containing reels and tape, which was introduced by Philips in 1964. Since the tape in the cassette was only 0.15 inch (0.38 cm) wide and moved at only 1⅞ inches per second, a pocket-size cassette could accommodate an hour-long recording.

An even smaller format, the "micro-cassette," running at a tape speed of $^{15}/_{16}$ inch (2.4 cm) per second, has largely replaced the standard cassette for recording dictation.

In recent years magnetic recording formats have diversified rapidly. Today's recorders may be classified in at least four ways: (1) by signal handling: audio-only or video with sound; (2) by physical form: open-reel or cassette; (3) by recording method: direct analog, frequency modulation (FM), or digital; (4) by head-tape relationship: stationary-head or helical-scan. Fixed-head design is used in analog recorders, while helical-scan is found in video recorders and digital audio tape (DAT) recorders.

Frequency modulation (FM), developed in the 1930s for broadcasting, was adapted for recording video signals and scientific data during the 1950s (see video recording).

Magnetic Tape. Although recording tapes have evolved in quality during the past half-century, their fundamental composition remains the same: a mixture of iron-oxide particles and lacquer coated on a thin plastic film.

The most widely used magnetic material is gamma-ferric oxide (Fe_2O_3), a form of finely powdered rust. "High-bias" audio tapes and most videotapes use chromium dioxide (CrO_2) or iron-oxide powder treated with cobalt. In high-performance "metal-particle" tapes, powdered iron is combined with other metals instead of oxygen.

Recording. A tape recorder consists of two systems: (1) a "tape transport" mechanism that moves the tape past the heads at a uniform speed; and (2) record-play electronics that prepare the signal for recording and amplify it in playback.

The actual recording or playback is done by a "head," a small electromagnet mounted in a shielded case. For recording, signal current generates a magnetic field in the head that is imposed on the magnetic particles in the tape. For playback, the magnetic fields in the moving tape generate tiny electric currents in the head.

Since a digital signal consists only of ones and zeros, a digital recording flips the magnetic pattern alternately full-north or full-south.

For analog recording, the audio signal is combined with a strong "AC bias" signal that alternates from north to south and back approximately 100,000 times per second. The result is that the audio waveform is faithfully represented by the percentage of north-forward particles at each location along the recorded track.

Copying Recordings. When an LP or CD is pressed, an entire hour of music is duplicated in each 30-second pressing cycle. To make prerecorded tapes, the master tape is run and copied from beginning to end, a process that occurs simultaneously on dozens of recorders. One of the principal attractions of a tape recorder is the ease with which it can copy existing recordings or tape live radio broadcasts.

A tape may be copied either by connecting two recorders together or by using a "dubbing deck," a recorder with two cassette compartments and internal connections for copying. This activity, like the photocopying of books and magazine articles, may be unethical if it violates the copyright of the person who created the original recording.

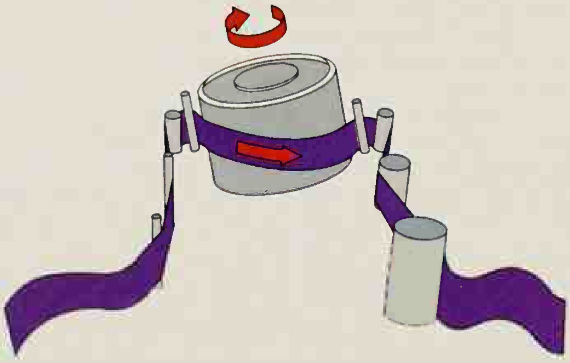
Digital Audio

In analog recording systems, a representation of the sound wave is stored directly in the recording medium. In digital recording what is stored is a *description* of the sound wave, expressed as a series of "binary" (two-state) numbers that are recorded as a simple on-off signal. The methods used to encode a sound wave in numeric form and accurately reconstruct it in playback were developed during the 1950s and 1960s, notably in research at the Bell Telephone Laboratories. Digital recording became practical about 1970 with the arrival of integrated-circuit chips that allowed the circuitry of a room-size computer to be shrunk to desktop size.

Sony and Japan Victor Corp. first made digital recording practical by manufacturing converters that store digital and audio signals on videotape. (Multitrack digital tape recorders used in studios, with 8 to 32 channels of sound, employ the open-reel format; but 2-channel digital recording uses the same helical-scan recording technique that is used for taping television signals.) By 1976 major record companies were making LPs from digital master tapes. Digital audio tape (DAT) recorders for consumer use were introduced in 1987.

Just as most digital audio recording is done on videotape, the compact disc (CD) digital record is based on technology created for the optical videodisc. The "Laservision" system, which uses a low-power laser to read a video signal encoded as a series of microscopic pits in a reflective disc, was developed by Philips in Holland during the mid-1970s, and was later adapted for digital audio as the compact disc recording.

The CD system was developed by Philips in Europe



In recording digital audiotape (DAT), two record/playback heads are mounted at different angles on opposite sides of a drum that spins at 2,000 rpm. Tape moves slowly and at a slant across the spinning drum, as the heads record parallel diagonal tracks whose patterns differ. In playback each head reads only its own track (see below). Some 2.5 million data bits—audio signals, error correction codes, tracking and indexing signals—are recorded each second on the 3.8-mm-wide tape.

and Sony in Japan. An industry committee adopted the CD format as an international standard, and CDs first appeared on the market in 1983. The CD is 12 cm (4.7 in) in diameter and contains up to 74 minutes of music in two-channel stereo, or up to 37 minutes of four-channel sound.

The success of the CD has spawned several alternative formats, including the CD-ROM, or CD–read only memory, containing 500 megabytes of computer-coded data or programs; and CD-I, or CD-Interactive, containing a mix of audio, video, and computer programming.

Sampling and Quantization. While there are many methods of representing a signal in digital code, the approach used for high-fidelity audio is called linear pulse code modulation, or PCM. It is a two-stage process using both sound sampling and binary quantization. At regular intervals (44,000 times per second), a "sample and hold" circuit momentarily freezes the audio waveform and holds its voltage steady, while a quantizing circuit selects the binary code that most closely represents the sampled voltage.

Error Correction. Much of the circuitry in a digital tape recorder or CD player is devoted to detecting and correcting any bit-reading errors that might be caused by microscopic tape flaws, disc-pressing defects, dust, or scratches.

Error correction is based on "parity" testing. When the recording is made, an extra bit is added at the end of every digital code, indicating whether the number of "ones" in the code is odd or even. In playback this parity count is repeated to detect whether any bits have changed.

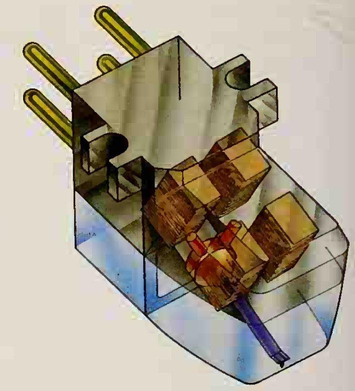
The Compact Disc. The digital code is engraved on the COMPACT DISC in the form of microscopic pits along a track that begins near the center of the disc and spirals outward toward the edge. The pits are approximately 0.5 micrometers (μm) wide, with a uniform 1.6-μm spacing that causes light to be diffracted in a colorful rainbow spectrum (1 μm is one-millionth of a meter, or 1/25,000 of an inch). Mass-production of CDs, like LPs, utilizes a master disc.

For playback, a laser is focused through the transparent rear surface of the disc onto the aluminized pits, and an optical sensor detects the alternately strong and weak reflection. Small scratches and dust particles on the plastic surface have little effect, since they are out of focus. The disc plays from the center out, rotating at about 500 rpm initially and gradually slowing to about 200 rpm as the spiral track approaches the rim, so that the pits pass under the laser beam at a constant linear speed of 1.25 meters (4 ft) per second.

Digital Audio Tape. Digital audio tape (DAT) machines made for at-home recording and in-car playback employ the same 16-bit PCM code as the CD. The digital code is recorded on tape in helical-scan format, like that of a VCR, using a smaller version of the mechanism in an 8-mm VCR.

Modern Stereo Systems

After World War II the near-simultaneous arrival of full-frequency-range disc recording, magnetic tape recording, and the long-playing record stimulated popular interest in HIGH FIDELITY sound and a rapid expansion of the record industry. Since then interest in better and more convenient sound reproduction has been stimulated by a constant parade of innovations—stereo tapes (1954); the compact acoustic-suspension loudspeaker (1955); stereo LP records (1958); stereo FM radio (1962); the spread of multitrack recording during the 1960s; the arrival of transistors during the same period, making equipment smaller, cheaper, and more reliable; Dolby noise reduction (1967); stereo cassette tapes (1970); four-channel sound (early 1970s); Dolby Stereo sound for movies (1976); digital recording (late 1970s); "Walkman" portable headphone stereo (1980); the compact disc (1983); the HiFi stereo VCR (1984); stereo television sound (1985); the DAT (1987); and so on.



In the stereo cartridge, the stylus vibrates as it moves along the record grooves. A tiny magnet on the end of the stylus bar moves in accordance with the vibrations and sets up a fluctuating current in the 4 rectangular wire coils (2 for each sound channel). The current passes through the tone arm and amplifier, and emerges as sound from the speakers.

Anatomy of a Stereo System. The following audio components, in combination, make up a complete stereo system.

The record player. This component consists of three subassemblies: a pickup cartridge whose stylus assembly traces the groove and translates its wiggles into an electrical signal; a tonearm that holds the cartridge above the groove with the correct downward tracking force; and a turntable whose motor spins the record at the required speed.

The tuner. This component receives RADIO broadcasts, usually from both AM and FM stations. In stereo FM, the quality of the reception depends as much on the antenna's size, aiming, and location—preferably on the roof—as on the quality of the tuner.

Amplifiers. An integrated, or complete, AMPLIFIER consists of a preamplifier and a power amplifier. The power amplifier drives the loudspeakers. It has a power supply (transformer and filter capacitors), plus an output stage that behaves as an electronic gate controlled by the audio signal, opening and closing to regulate the flow of current from the power supply to the loudspeakers. The flow of electric current through each loudspeaker's voice coil causes it to vibrate back and forth, producing sound.

The preamplifier has two functions: it amplifies and equalizes the very small signal produced by the stereo cartridge and allows change between the other inputs—tape cassette, tuner, and so forth; and it includes volume and tone controls.

The RECEIVER is a tuner and an integrated amplifier, combined in a single chassis for convenience and economy.

Loudspeaker. A LOUDSPEAKER system usually consists of two or more drivers (woofer, midrange, tweeter); a crossover circuit that channels low frequencies to the woofer, high frequencies to the tweeter, and so on; and a cabinet.

Headphones. Headphones are simply miniature loudspeakers that are aimed directly into the ears. They provide dramatic stereo separation and vivid clarity, without the blending that occurs when sounds bounce around in a room, and they require so little power that they can be driven from battery-operated radios and tape players.

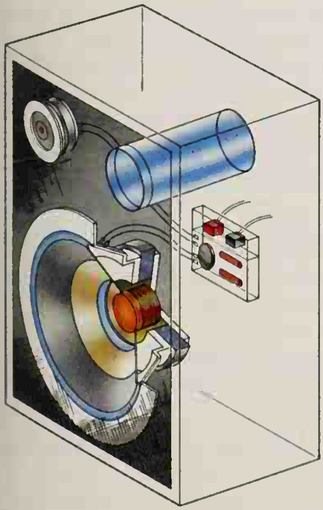
Other Components. In addition to a record player and a tuner or receiver, a modern stereo system is likely to include a compact disc player and a tape recorder.

A stereo system may also include signal-processing accessories that manipulate and enhance sound, such as a graphic equalizer (an elaborate tone-control device), a dynamic-range expander, a sub-woofer for more powerful bass, or a surround-sound unit with extra loudspeakers to reproduce the spaciousness of sound that can be heard in a concert hall.

Rating Performance. While educated ears are the best judge of any sound-reproduction system, many of the desirable performance qualities of audio equipment can be measured in laboratory tests, which give ratings for distortion and noise, output power, dynamic range, and frequency response.

Component Placement. Most stereo equipment can be installed wherever it proves most convenient, with two exceptions. A record player should be on a stable, vibration-free shelf. And for good stereo, the loudspeakers must be equally distant from the listener.

Noise Reduction. All recording processes add some low-level noise to the reproduced sound. LP records have high-frequency hiss, caused by minute groove irregularities, and low-frequency "rumble"—often due to vibration from the turntable motor and bearings. Tapes add hiss because of the imperfectly random distribution of magnetic particles in the binder. Digital recordings have low-level "quantizing" noise because of the finite number of "bits" used to measure the signal. Even purely electronic circuits add noise because of tiny irregularities in the flow of electrons.



The bass reflex loudspeaker consists of two transducers, or drivers, that convert electrical signals from the amplifier into acoustic signals, or sound: a large woofer that handles low frequencies, and a smaller tweeter for higher frequencies. The drivers are housed in an enclosure, which also contains a suspended port, to augment low sound frequencies, and a crossover network, an electronic filter circuit that directs frequencies to the appropriate driver.

Much of the excellence of modern sound reproduction is due to processes that reduce background noise so that every detail of the recorded sound is clearly audible against a background of relative silence. The first of these processes is "equalization," or EQ, used in every recording medium. The naturally weak high-frequency overtones in music are boosted by a standard amount during recording; then in playback the highs are cut back by the same amount, restoring the original tonal balance and reducing noise added by the medium.

To suppress background noise more thoroughly, noise-reduction circuits operate by compressing the dynamic range of the signal during recording, thereby boosting the level of the quietest sounds, especially at high frequencies. The process is reversed during playback, pushing the quiet sounds down to their original level and pushing noise down at the same time. Dolby Laboratories has created the most widely used noise-reduction systems for professional studio and cassette recording, motion picture sound tracks, and stereo television sound. DBX provides similar systems.

Sound Recording on Film

As early as the 1890s, Thomas Edison produced a series of "talking kinetoscopes," motion pictures that were accompanied by sound from cylinder phonographs (see CINEMATOGRAPHY). Many other attempts were made to bring sound to the movies, but all faced the same obstacles: inadequate volume to fill a theater and uncertain synchronization between sound and picture. Both problems were ultimately solved by Lee De Forest. His invention of the Audion vacuum tube paved the way for electrically amplified sound reproduction, and during the 1920s he developed a "Phonofilm" system for recording sound directly on the film. By 1930, Phonofilm had been adopted by the major film studios, and, with refinements, it remains the basis of optical film sound to this day.

The optical sound track is recorded in the narrow space between the edge of the picture frame and the sprocket holes. The exposure of the sound track is controlled by a light valve consisting of a pair of metal ribbons that flex when driven by the amplified audio signal, admitting varying amounts of light to the film. When the developed film is projected, the sound track transmits varying amounts of light to a photoelectric cell, generating an electrical signal that is amplified to drive a loudspeaker. Some films are produced with magnetic sound tracks for use in specially equipped theaters.

In a motion-picture theater, the loudspeakers are located behind the screen, which is perforated with many small holes to let the sound pass freely. Additional speakers may be installed along the walls for "surround" effects.

In a Nashville, Tenn., studio a musician composes and records, using banks of synthesizers and a sound equalizer, all connected to a computer. He may record his music directly on tape, or store it in digital form within the computer, or computer-print it as he composes.

The Recording Industry

History. Since the early days of the Edison wax cylinder, the recording industry has been a complex mixture of art and highly profitable commerce, aided both by the universal appeal of music and by worldwide standardization of every important recording format. Records and tapes of today's popular artists are heard around the world—a situation that is strikingly different from other media industries. (Because of language differences, book and magazine distribution tends to stop at national boundaries; the international sale of videocassettes is crippled by incompatible television formats.)

The recording industry has had two immensely profitable "golden" eras. The first spanned the three decades from the arrival of the mass-producible disc record in 1901 until about 1930. The second has extended from the early 1950s to the present day. Before and during World War I, records were the most popular form of home entertainment. After a brief postwar slump, the arrival of electrical recording in 1925 stimulated a strong resurgence in record sales during the late 1920s. But the Depression of the 1930s and the growth of radio—which offered entertainment at no cost—reduced record sales by 93 percent in just four years. The industry was saved by the repeal of Prohibition in 1933: records were needed to restock JUKEBOXES in reopened taverns and lounges all over the country.

After World War II, television spawned the industry's second golden era. When TV took over the programs that had been radio's mainstay, radio stations turned to playing records full-time, providing unlimited exposure for the record industry's product.

With this saturation campaign of free advertising on the radio, plus the allure of long-play records and high-fidelity sound, record sales boomed. The arrival of the small, portable transistor radio gave teenagers the freedom to listen privately, away from the living room. Annual U.S. recording sales grew from $200 million in the early 1950s to over $7 billion (1989), spurred by the success of compact discs, which were rapidly overtaking cassettes as the most popular recorded medium.

Recording Music. There are two basic approaches to making present-day recordings. In documentary-style recording, the goal is to capture a musical performance and produce a recording that sounds substantially like a concert. If the performers are few in number they visit a recording studio. If the ensemble is large, like a symphony orchestra, recording equipment is brought to the concert hall. When a satisfactory recording of the entire performance has been obtained, the edited tape is copied and used to produce LPs, cassettes, and CDs.

For many rock groups a recording studio is an experimental laboratory where sounds are invented and a performance is assembled, one track at a time. A recording may begin as a vocal line or a rhythmic pattern on one track of a 24-track tape. Additional tracks (piano accompaniment, keyboard synthesizer, drums, guitar flourishes) are recorded individually. Next, various tracks may be enhanced by using signal processors to add "effects." Finally all of the tracks are mixed and remixed until a satisfactory result is achieved. The aim is to achieve a record that stands on its own merits as an artistic achievement, independent of whether it can be duplicated in concert.

A new kind of recording technology, derived from research in the creation and recording of ELECTRONIC MUSIC, is beginning to make the studio recording process much more flexible. Called "tapeless" recording, it stores digitally coded sound in the random access memory (RAM) of a specially equipped computer, and on the computer's hard disc for permanent storage. Using RAM gives the recording technician almost instantaneous access to what has just been recorded, a feature that can be immensely valuable in dubbing additional sounds or patching imperfect notes. If the computer is used to transmit musical instructions to electronic instruments, the resulting music is known as COMPUTER MUSIC.

A recording studio consists basically of two rooms: a large room that has been carefully soundproofed so that sounds can he recorded accurately with the assurance that no unwanted noise will intrude; and a small "monitoring" room containing the tape recorders, mixers, effects processors, and high-quality loudspeakers that can be used to evaluate the recording.

GLOSSARY OF AUDIO TERMS

Note: terms followed by an asterisk (*) have separate entries in this encyclopedia.

acoustic suspension	A type of loudspeaker* in which the motion of the woofer cone is stabilized by air pressure within the sealed cabinet.
AM	(amplitude modulation*) A method of broadcasting in which the desired audio or video signal modulates the amplitude of a "carrier" signal.
antenna*	An array of metal rods or wires used to intercept radio waves and convert them into electrical currents.

bandwidth The range of frequencies over which a device operates effectively.

bass The lowest audible frequencies, between approximately 20 and 200 cycles per second.

bass reflex A type of loudspeaker whose low-frequency response is augmented by sound waves emerging from within the cabinet via a port or freely suspended cone. Also called a "ported" or "vented" speaker.

bias In tape recording, an ultrasonic signal that is mixed with the audio signal during recording. Bias reduces noise and distortion and affects the frequency response.

binaural Stereo recordings that are made with microphones mounted in a dummy head and intended for playback through headphones.

cartridge The phonograph pickup, consisting of a stylus assembly and the miniature circuits that transform stylus vibration into an electrical signal.

CD (compact disc*) A digitally encoded record, aluminized to reflect light and played with a low-power laser. A 12-cm (4.7-in) CD contains up to 74 minutes of stereo sound.

CD-V (compact disc-video) A variant form of CD containing up to 5 minutes of video and 20 minutes of digital audio.

coaxial Refers to devices having the same center. In a coaxial speaker, the tweeter is mounted in the center of the woofer. A coaxial cable consists of a central wire surrounded by insulation and an outer wire forming a cylindrical shield against interference.

crossover An electronic filter circuit that separates low from high frequencies and channels them to the woofer and tweeter, respectively.

DAT Digital audio tape, usually packaged in a cassette. DAT employs the same digital coding and provides the same sound quality as the compact disc.

DBX An audio equipment manufacturer and developer of noise-reduction systems used in tape recording and in stereo television sound.

digital (1) A method of representing sound waves as a series of binary numbers. (2) A tuning method for radios, in which the desired frequency is set by digital calculation. (3) A numeric display of information.

direct drive A turntable drive system in which the spindle and platter are part of the motor itself.

distortion Changes in a signal that involve the addition of spurious tones at frequencies not present in the original sound. In "harmonic" distortion the spurious tones are at integral multiples of the original frequency. In "intermodulation" distortion, discordant tones appear at the sums and differences of two original frequencies.

Dolby A, B, and C Three noise-reduction circuits for tape recorders, invented by Ray Dolby.

Dolby Stereo A system of noise-reduction and equalization for improved motion-picture sound.

dropout A momentary loss of signal in a tape recording, usually caused by wear, dust, or a tape defect.

dubbing (1) The process of copying a recording to make a duplicate. (2) In motion-picture sound, replacing a foreign-language soundtrack with dialogue in the language of the audience.

dynamic range The ratio between the loudest and softest sounds that can be reproduced accurately by a recording medium.

equalization Changes in amplification at low or high frequencies, done to compensate for the limitations of a recording medium and to obtain equally accurate reproduction at all frequencies.

flutter Unwanted variation in the speed of a turntable or tape recorder. Slow flutter, or "wow," causes musical sound to waver in pitch.

FM (frequency modulation*) A method of broadcasting or recording in which the desired audio or video signal modulates (varies) the frequency of a "carrier" signal.

FMX (Extended-range FM) A noise-reduction system that permits hiss-free reception of FM broadcasts at large distances or with small antennas.

frequency response The principal measure of the fidelity of any sound-reproducing device.

graphic equalizer A tone-control device whose amplification can be varied octave by octave, using slider controls whose positions provide an approximate visual graph of the frequency response.

impedance Opposition or resistance to the flow of electrical current. The rated impedance of a loudspeaker is an average, since the impedance depends on the frequency of the signal.

LED (light-emitting diode) Solid-state devices that glow when electric current is applied.

loudness compensation A tone-control process that boosts low frequencies at low volume levels, in an attempt to compensate for the ear's insensitivity to quiet bass sounds.

midrange Frequencies in the range spanned by the human voice, from approximately 200 to 2,000 cycles per second.

monophonic, monaural Recording or playback involving only one channel of sound.

multipath Reception of one or more reflected signals along with a direct broadcast signal, producing distortion in stereo FM and ghost images in television.

multiplex A method of accommodating two channels of information on one carrier, for example, two channels of sound in one FM broadcast.

phase The relative timing of two signals. If signals are "in phase," they are precisely synchronized. If loudspeakers are wired "out of phase," one is "pushing" when the other is "pulling."

preamplifier The portion of an amplifier* that amplifies phono signals and includes most operating controls.

power amplifier The portion of an amplifier that produces the high current levels needed to drive a loudspeaker.

quadraphonic Surround-sound reproduction involving the recording and playback of four channels of sound.

quantization The representation of a continuous quantity, such as a sound wave, by a series of numeric values.

receiver Generally speaking, any device that receives broadcasts. In hi-fi, an integrated amplifier and radio tuner combined in the same chassis.

resonance The natural tendency of a device to vibrate at a specific frequency. Unwanted resonances in loudspeakers, for example, alter the sound by producing excessive response at some frequencies.

rumble Low-frequency noise caused by vibration of the motor and bearings of a turntable.

sampling Part of the process of digital recording—dissection of a signal in time, preparatory to quantization.

selectivity A measure of a tuner's ability to receive stations at closely spaced frequencies without mutual interference.

S/N ratio (signal-to-noise ratio) The range, usually expressed in decibels, between the loudest sound a recording medium can accommodate and its background noise level.

stereophonic Sound reproduction that uses two or more channels in order to represent the size or spatial distribution of sound sources.

surround Sound reproduction that surrounds the listener with sound, as in quadraphonic recording and reproduction.

THD (total harmonic distortion) A measure of all of the spurious signals added by a sound-reproducing device.

tone control A method of altering the timbre of reproduced sound by increasing or decreasing the amplification at either high or low frequencies.

track The area on a tape where a signal is recorded.

tracking force The downward force applied to a stylus to maintain uniform contact with the undulating groove wall.

transducer A device that changes a signal to a different physical form while maintaining its pattern: as in the phono cartridge, which transforms stylus motions into electrical signals, or the loudspeaker, which transforms electrical signals into sound waves.

transport The portion of a tape recorder that moves the tape past the heads at constant speed.

treble The highest audible frequencies, between approximately 2,000 and 20,000 cycles per second.

tweeter A small loudspeaker that reproduces high frequencies.

watt A unit of electrical or acoustical power. Electrical power is the product of voltage and current. Acoustical power is proportional to sound-pressure intensity.

woofer A large loudspeaker that reproduces low frequencies.

wow Slight variations in the speed of a tape or record player, causing the musical pitch to wobble.

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sounding rocket Sounding rockets are research rockets that carry data-gathering equipment into the atmosphere at altitudes that are too low for the operation of SATELLITES and too high for BALLOONS. These altitudes usually range from about 32 km (20 mi) to 160 km (100 mi), although sounding rockets may occasionally ascend to altitudes of hundreds of kilometers. The data gathered by the rockets' equipment may be telemetered to Earth in the form of electronic signals, or the entire apparatus may be designed for recovery. Sounding rockets have been used since the mid-1940s, when captured German V-2s were used by the United States. The U.S. Navy used V-2 technology to develop the Viking rocket, followed by the highly successful AEROBEE series. Many types of sounding rockets have since been developed by many countries.

Meteorological research requires rockets that can ascend to altitudes of 16 to 80 km (10 to 50 mi) to measure pressure, temperature, air density, and winds. Rockets in this category have included the U.S. Loki-Dart, the British Skua, the Japanese MT-135P, and the Soviet M-100-B. Larger, mid-range sounding rockets ascend into the upper atmosphere, where physical properties are often highly variable because of such factors as sunspots and solar flares. Typical areas of study involving mid-range rockets are the electron and ion content of the atmosphere, the Earth's magnetic field, and the aurora. Research rockets serving these needs have included the U.S. Aerobee 200, the British Skylark, Canada's Black Brant 5B, France's Dragon 3, and Japan's K-9M.

High-altitude research rockets, which may ascend to hundreds of kilometers, gather and return data on cosmic rays, the Van Allen radiation belts, ultraviolet rays, X rays, solar flares, micrometeoroids, and many other phenomena. Examples of rockets that have been used for high-altitude research include the U.S. Astrobee 1500, the Japanese L-3H, and the Soviet Vertikal series of rockets.

Sounding rockets typically are used in developing advanced sensing instruments to be placed aboard space satellites and probes, to calibrate research satellites as they pass overhead, and for a wide range of other tasks.

See also: ROCKETS AND MISSILES.

Souphanouvong [soo-fah'-noo-vahng] Prince Souphanouvong, b. 1902, served as head of the Lao People's Democratic Republic from December 1975 until his retirement in October 1986. Souphanouvong studied engineering in France, and after World War II fought against the French. He joined the communist insurgent (Pathet Lao) forces and became their leader, representing them at the Geneva Conference (1961–62). He was included (1974) in a coalition government under the premiership of his half brother Prince SOUVANNA PHOUMA, whom he ousted in 1975.

sourwood Sourwood, *Oxydendrum arboreum,* also known as sorrel tree, is native to the southeastern United States. About 15 m (50 ft) in height, it produces small white flowers in branching clusters during the summer. Its large, sour-tasting leaves are chewed by hikers to relieve thirst. Sourwood honey is a product of the southern Appalachian region.

Sousa, John Philip [soo'-zuh] America's greatest composer of MARCH music was John Philip Sousa, b. Washington, D.C., Nov. 6, 1854, d. Mar. 6, 1932. The popularity of his 136 marches—headed by "The Stars and Stripes Forever" (1896)—gained him the title the March King, but he also composed 15 operettas, 70 songs, and 27 fantasies and wrote more than 300 arrangements, as well as 132 articles and 7 books.

At the age of 13, Sousa enlisted as an apprentice in the U.S. Marine Band. He left the Marines when he was 18 years of age and played violin in theater and symphony orchestras. He became leader of the Marine Band in 1880 and began composing; his first hit march was "The Gladiator" (1886), and his "Washington Post March" (1889) became a ballroom rage associated with a new dance, the two-step.

He left the Marines in 1892 to form his own band, which quickly became the most successful in the nation; tours through Europe in 1900, 1901, 1903, and 1905 and a global circuit in 1910–11 brought him worldwide celebrity. With the U.S entry into World War I, Sousa led the Navy Band, and he continued an active musical life until his retirement in 1931.

Souter, David H. [soo'-ter] David Hackett Souter, b. Melrose, Mass., Sept. 17, 1939, became in October 1990 an associate justice of the U.S. Supreme Court, appointed by President George Bush. A graduate of Harvard University (B.A., 1961; LL.B., 1966) and a Rhodes scholar at Oxford (1961–63), Souter was New Hampshire attorney-general (1976–78), a State Supreme Court justice (1983–90), and a U.S. Court of Appeals judge (1990).

South Africa The Republic of South Africa occupies the southernmost portion of the African continent, stretching from the Limpopo River in the north to Cape Agulhas (see Agulhas, Cape) in the south. The Indian Ocean lies to the east and the Atlantic Ocean to the west. The strategic sea route around the Cape of Good Hope (see Good Hope, Cape of) has long made South Africa important in world commerce.

South Africa shares boundaries with Namibia, Botswana, Zimbabwe, Mozambique, and Swaziland, and it completely surrounds the independent nation of Lesotho. The country consists of four provinces—Cape Province and Natal (former British colonies) and the Orange Free State and Transvaal (former Boer republics)—and ten black-African "homelands." Four of these homelands—Transkei, Ciskei, Bophuthatswana, and Venda—have been granted "independence" that is recognized only by South Africa and themselves. The country has three capitals: Pretoria (administrative), Cape Town (legislative), and Bloemfontein (judicial).

The South African economy is the most diversified and developed in Africa, but enormous differences exist between the economies of the homelands and white areas, and there are significant economic, social, and political differences between racial groups. Although there have been recent reforms and a government promise to elimiate apartheid ("apartness" in Afrikaans), a system of legalized racial separation that was rigidly enforced by the ruling white minority from 1948, the black majority is still excluded from national political life.

Land and Resources

South Africa has a great diversity of natural landscapes and resources. Its 2,955-km (1,836-mi) coastline has

AT A GLANCE

REPUBLIC OF SOUTH AFRICA

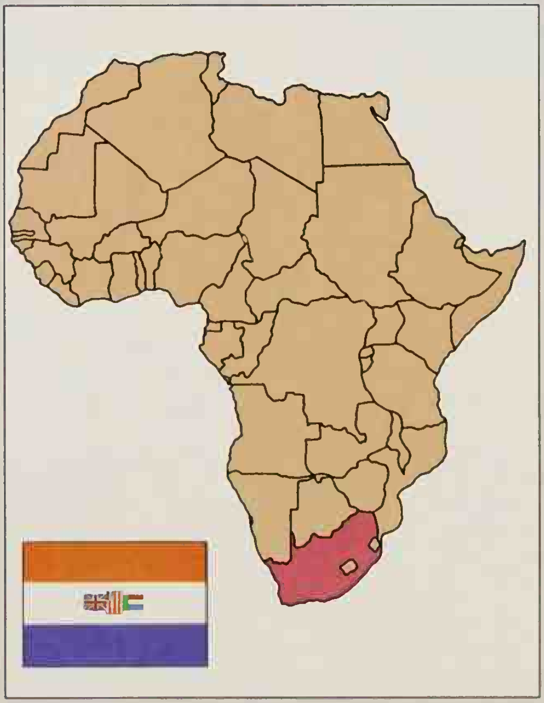
Land: Area: 1,221,037 km^2 (471,445 mi^2). Capitals: Pretoria (administrative, 1985 pop., 433,059); Cape Town (legislative and largest city, 1985 pop., 776,617); Bloemfontein (judicial, 1985 pop., 104,381).

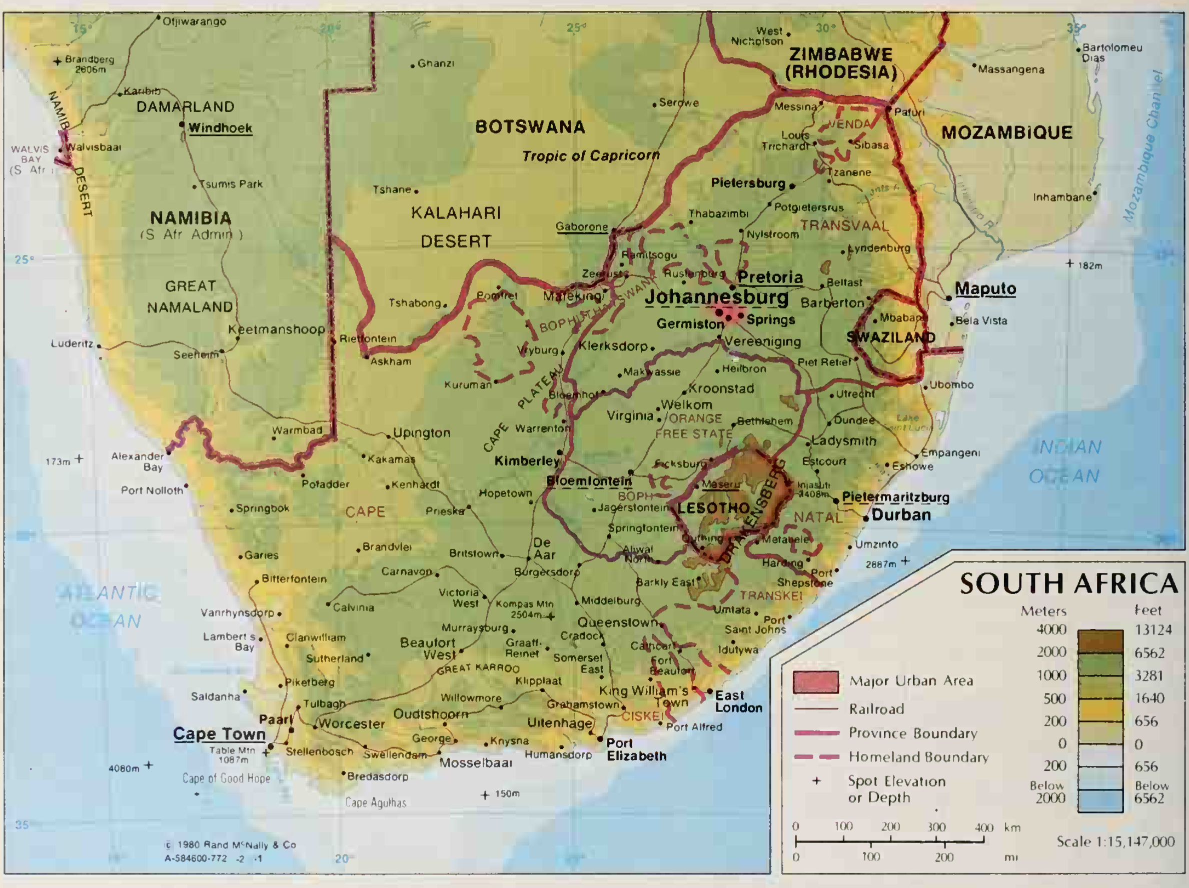
People: Population (1990 est.): 39,549,941. Density: 32.4 persons per km^2 (83.9 per mi^2). Distribution (1989): 56% urban, 44% rural. Official languages: Afrikaans, English. Major religions: traditional African religions, Dutch Reformed church, Anglicanism, Roman Catholicism, Methodism, Hinduism, Judaism.

Government: Type: republic. Legislature: tricameral—House of Assembly (white), House of Representatives (Coloured), House of Delegates (Asian). Political subdivisions: 4 provinces, 10 Bantu "homelands" (4 "independent").

Economy: GNP (1989): $86 billion; $2,460 per capita. Labor distribution (1985): agriculture—30%; industry and commerce—29%; services—34%; mining—7%. Foreign trade (1989 est.): imports—$18.5 billion; exports—$21.5 billion. Currency: 1 rand = 100 cents.

Education and Health: Literacy (1989): whites—virtually 100% of adult population; blacks—50% of adult population. Universities (1988): 18. Hospital beds (1984): 140,791. Physicians (1988): 22,096. Life expectancy (1990): women—67; men—61. Infant mortality (1990): 52 per 1,000 live births.





few natural harbors and is rimmed by a narrow, undulating coastal lowland that gives way to a series of folded sedimentary mountain ranges collectively known as the Cape Ranges. Farther east is the DRAKENSBERG, which parallels the Indian Ocean northward into the eastern Transvaal. South Africa's highest peak, Injasuti (3,408 m/11,181 ft), is in the Drakensberg near the Lesotho border.

The Drakensberg and its outward-facing escarpments (the Great Escarpment) separate the coastal lowlands of Natal and the Cape from the high interior plateaus commonly known as the highveld. Here elevations range from 1,220 to 1,830 m (4,000 to 6,000 ft). The terrain is undulating and broken in places by isolated hills and low mountain ridges, the principal being the gold-bearing WITWATERSRAND that trends east-west across the southern Transvaal. The highveld contains most of South Africa's extraordinary mineral wealth—gold, diamonds, coal, iron ore, copper, manganese, and asbestos.

Along the northwest border with Botswana, the high plateau gives way to the KALAHARI DESERT. Between the Cape Ranges and the Great Escarpment lies the Great Karoo, a broad, semiarid basin of mesas and buttes.

Drainage. None of South Africa's rivers is navigable, primarily because of inadequate rainfall and broken terrain. Most of the interior plateau is drained by the ORANGE RIVER and its two main tributaries, the Vaal and the Caledon. The Limpopo forms part of South Africa's northern boundary and drains much of the Transvaal. Smaller rivers rise in the Drakensberg and cut deep valleys across the foothills and lowlands of Natal, Transkei, and the eastern Cape.

Climate. South Africa has great climatic diversity. A Mediterranean climate prevails in the southwest around Cape Town, whereas a humid subtropical climate occurs along the Natal coast. Much of the northern highveld has a savanna climate, while temperate steppe conditions prevail in the Orange Free State and southern Transvaal. Semidesert and desert climates are found in the Cape interior and northwest. The mean annual temperature ranges from 23° C (73° F) in the north to 12° C (54° F) in the southern and eastern regions.

The highest precipitation (more than 1,000 mm/40 in. a year) occurs in the Drakensberg and coastal Natal. The lowest (less than 200 mm/8 in. a year) occurs along the Namaqualand coast north of Cape Town. About 65% of the country receives less than 500 mm (20 in) of precipitation annually.

Soils, Vegetation, and Wildlife. Most South African soils are low in humus content and are not especially fertile. Less than 0.2% of the land is naturally forested. Savanna vegetation occurs in the northern Transvaal and eastern lowveld, and grasslands cover the highveld and dry southwest. Elephants, rhinoceroses, giraffes, zebras, antelopes, and other wildlife are protected in such game reserves as Kruger National Park, Hluhluwe, and Mkuze.

People

South African law recognizes four racial groups: indigenous Africans, or blacks (74% of the total population); whites (14%); Coloureds (9%); and Asians (3%). The Africans may be divided into four major ethnolinguistic groups: the NGUNI (including the XHOSA, ZULU, Swazi, and Ndebele), who are concentrated east of the Drakensberg and constitute 60% of South Africa's Bantu-speaking peoples; the SOTHO (including the Tswana, Pedi, and Basotho), who live primarily in the Transvaal, northern Cape, and Orange Free State; and the Venda and Thonga peoples of the northern Transvaal. A small number of Khoisan-speaking peoples—the SAN (Bushmen) and KHOIKHOI (Hottentots)—live in and near the Kalahari Desert.

Under the policy of separate or multinational development, the South African government recognized ten black "nations," defined in ethnolinguistic terms, each of which was assigned to a homeland. Approximately 55% of all blacks lived outside their prescribed homelands, which constituted only 13% of South Africa's total land area. In 1990 the government announced its willingness to abandon the unpopular homelands policy as part of a broader political settlement.

The whites form the second largest racial group and dominate South Africa's political and economic institutions. They comprise two main groups: AFRIKANERS (60% of the total), who are descended from 17th-century Dutch settlers in the Cape and refugee French Huguenots and German Protestants; and the English-speaking group (34% of the total), who are descendants of British settlers who arrived as early as 1820 and more recent immigrants from the United Kingdom and former British colonies in Africa, especially Zimbabwe and Kenya. There are also many recent immigrants from Germany, Italy, Greece, and the former Portuguese colonies of Angola and Mozambique. The great majority of non-Afrikaner whites in South Africa hold or are entitled to foreign passports. Almost 90% of the whites are urban dwellers.

The Coloureds are persons of mixed race whose origins date to the 17th century when Europeans interbred with local Africans and imported Malay slaves. They live mostly in the western Cape and form the largest racial group in metropolitan Cape Town. Three-fourths are urban dwellers.

The Asians are concentrated in Natal, especially metropolitan DURBAN. Because their forebears came from many different parts of the Indian subcontinent in the late 19th century, they are ethnically and linguistically diversified. Most Asians are urban dwellers.

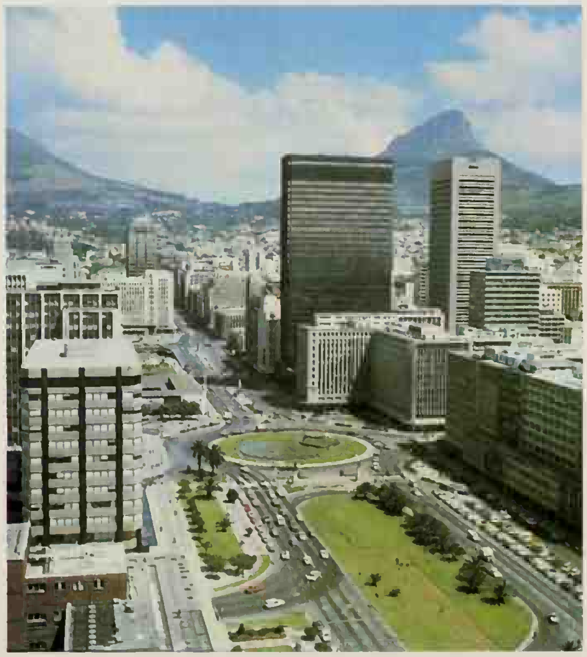
Demography. South Africa's annual rate of population growth is highest among blacks (2.8%) and lowest among whites (0.18%). White immigration is encouraged by the government. Internal migration is primarily of blacks from the homelands to the cities (where most jobs are). In 1986 the hated pass laws, requiring blacks to have specially stamped passbooks to remain in white areas for more than 72 hours, were abolished. Between 1960 and 1985 it is estimated that about 3.5 million blacks—plus much smaller numbers of other races—were moved against their will to conform to apartheid regulations specifying where people of various races could live. Reforms proposed in 1991 to end discrimination in land ownership and residential living ruled out reparations for people thus dispossessed.

JOHANNESBURG, the center of the nation's industrial core, has been overtaken as the largest city by Cape Town and Durban, the country's principal port. Other large cities include Bloemfontein, EAST LONDON, Germiston, KIMBERLEY, PIETERMARITZBURG, PORT ELIZABETH, and Pretoria. Laws forbidding blacks to live in white areas or buy land outside tribal homelands were repealed in 1991.

Language and Religion. Afrikaans and English are the official languages. Afrikaans, derived from Dutch, is the mother tongue of the Afrikaners and the principal language of the Coloureds. Most urban blacks speak English and Afrikaans in addition to their native language. The Bantu languages (see AFRICAN LANGUAGES) are not mutually intelligible. Many blacks speak Fanakalo, a lingua franca that developed among black workers in the mines.

The politically influential Dutch Reformed church,

Cape Town, a provincial capital and the seat of the South African Parliament, is the nation's leading Atlantic port. The oldest European settlement in South Africa, Cape Town was founded in 1652 as a supply base for the Dutch East India Company.



Conical thatched roofs and earthen walls are characteristic of residences built by Bantu peoples of eastern South Africa. The South African government has resettled many blacks into homelands known as Bantustans.

which professes a type of fundamentalist Calvinist Protestantism, has almost 4 million members, primarily Afrikaners and Coloureds. The Roman Catholic church claims 2.4 million adherents. The Anglicans, whose spiritual leader is Bishop Desmond TUTU (a black awarded the Nobel Peace Prize in 1984 for his leadership in the struggle against apartheid), claims 2 million members, as do the Methodists. Most Africans belong to black independent churches or follow traditional religious practices. Three-fourths of the Asians are Hindu. There is a small Jewish community.

Health and Education. Wide disparities exist between races in health indicators and facilities. Life expectancy at birth is 59 years for blacks and Coloureds, 65 years for Asians, and 72 years for whites. Infant mortality rates are 80 per 1,000 for blacks and 13 per 1,000 for whites.

Education has been under the control of a single government agency since 1985 except in the homelands. Schooling is compulsory for all whites and most Coloureds between the ages of 7 and 17 and for Asians between the ages of 7 and 14. Compulsory education for blacks between the ages of 7 and 16 began to be phased in in 1981, but many black children do not attend school. Expenditures for black education have increased, however, and moves to create a unified educational system began in 1991. Ten universities cater to whites. There are five universities for blacks, and one each for Coloureds and Asians. The University of South Africa, a correspondence university, is open to all races.

The Arts. African art, dance, and literature have gained international acclaim and popularity (see AFRICAN ART; AFRICAN LITERATURE; AFRICAN MUSIC). Albert LUTHULI, author of *Let My People Go* (1962), was South Africa's first Nobel laureate (for Peace, 1960). Other prominent black writers include Thomas MOFOLO, B. W. Vilikazi, Peter ABRAHAMS, and Ezekiel Mphalele. Internationally known white authors who write in English include Athol FUGARD, Alex LA GUMA, Nadine GORDIMER, Alan PATON, Stuart Cloete, and Roy Campbell. André Brink, Uys Krige, J. M. Coetzee, Breyten BREYTENBACH, Ingrid Jonker, and Etienne Leroux are prominent Afrikaner writers, while Dennis Brutus and Adam Small are important Coloured authors.

Economic Activity

The discovery of diamonds near Kimberley (1867) and gold on the Witwatersrand (1886) helped transform South Africa from a land of subsistence farmers into a modern industrial state controlled by the white minority but reliant on black labor. Today South Africa is the strongest industrial economy on the African continent, although development occurred unevenly. White areas witnessed rapid industrialization and economic growth, while the homelands remained economically disadvantaged.

Agriculture and Fishing. Despite the limited supply of arable land (about 12% of the total area), South Africa is virtually self-sufficient in foodstuffs, although the homelands must import 45% of their food. The chief subsistence crops are corn and sorghum. The principal cash crops, grown almost exclusively by whites, are sugarcane, corn, wheat, citrus fruit, cotton, tobacco, and grapes. Cattle and sheep raising are also important, and fishing is a major industry.

Mining and Energy. Minerals account for about 70% of the country's foreign-exchange earnings. South Africa leads the world in the production of gold, chrome, and vanadium and is among the leading producers of gem and industrial diamonds, uranium, antimony, asbestos, manganese, and platinum. Petroleum and bauxite are the only major industrial resources that have not been found in commercial amounts. South Africa also possesses 60% of all African coal reserves.

Coal mined domestically provides nearly 80% of South Africa's primary energy needs. The country is the world's leading producer of synthetic fuels. About 70% of all electricity generated on the African continent is generated in South Africa, which is a major supplier of electricity to Lesotho, Swaziland, Botswana, and Mozambique.

Industry. The South African government has encouraged the growth of industry to make the country self-sufficient and independent of external pressure. Factories in the southern Transvaal (Witwatersrand) account for about half of the country's manufacturing, and the region is the most diversified industrial zone in Africa. A further 25% of manufacturing income is derived from the port cities of Cape Town, Durban, Port Elizabeth, and East London. Most South African manufactured goods are marketed domestically, and manufacturing is the leading contributor to the annual GDP. Leading industries include food processing, metalworking, and the manufacture of clothing, textiles, iron and steel, and machinery.

Trade. The country's chief exports are gold (which accounts for nearly half of all export earnings), other metals and metal products, foodstuffs, diamonds, chemicals, machinery, and transportation equipment. South Africa is the leading trade partner in a customs union that includes Namibia, Botswana, Lesotho, and Swaziland and is the dominant economic power in the southern third of the African continent. Lesotho, Mozambique, Malawi, Botswana, and Swaziland are also heavily dependent on remittances from workers employed in South Africa, particularly in the gold mines. In 1979, in an effort to lessen their dependence on South Africa, nine black-ruled nations in the region formed the Southern African Development Coordination Conference.

Government

A constitution approved by white voters in 1983 replaced the formerly all-white parliament with a multiracial, tricameral legislature. Each chamber exercises authority over the affairs of its own community. Foreign policy, defense, taxes, law and order, and other general affairs are considered by standing committees representing all three chambers. The membership of the three chambers—white (178), Asian (45), Coloured (85)—guarantees whites a legislative majority.

The new constitution abolished the presidency and prime ministership and made the head of government a state president with power to appoint the cabinet and control the President's Council (a multiracial body that replaced the upper house of parliament in 1980 and can resolve disputes among the legislative chambers). P. W. BOTHA, head of the NATIONAL PARTY that has held power since 1948, became state president in 1984, when the new constitution came into effect. Botha resigned the presidency in August 1989 and was succeeded by F. W. DE KLERK, who had become party leader in February and remained in office after elections in September.

Under the theory of separate development, all blacks were to become citizens of one of the ten homelands and be stripped of their South African citizenship as the homelands were declared independent. Some political concessions were later made to blacks living in white South Africa. After negotiations between de Klerk and black leader Nelson MANDELA began in 1990, the government said that the homelands policy would be abondoned as part of an overall settlement. By mid-1991, Mandela and de Klerk had agreed that a new constitution must contain a bill of rights and create a two-chamber parliament with some form of proportional representation. In April 1991, Mandela's AFRICAN NATIONAL CONGRESS (ANC) issued a constitutional outline calling for the creation of a unitary state based on the principle of one person, one vote, with an elected president and an independent judiciary.

History

The first known inhabitants of present-day South Africa were San and Khoikhoi hunters and gatherers; they were followed southward by Bantu-speaking peoples between AD 1000 and 1500. In 1488, Portuguese mariners led by Bartolomeu DIAS rounded the Cape of Good Hope. The Dutchman Jan van Riebeeck established the first European settlement at Table Bay (now Cape Town) in 1652 as a station for the Dutch EAST INDIA COMPANY. Dutch pioneers spread eastward, and in 1779 war broke out between Xhosas migrating south and the Dutch near the Great Fish River.

Britain controlled the Cape sporadically during the Napoleonic Wars and formally received the territory in 1814. Large-scale British settlement began in 1820. To preserve their Calvinist way of life, the Dutch (Boer) farmers began (1836) to move into the interior on the so-called GREAT TREK. In 1838 approximately 70 of the Voortrekkers were massacred by Zulus. Seeking vengeance, Andries PRETORIUS led the Boers against the Zulus, defeating them in the Battle of Blood River. The Voortrekkers eventually established independent republics, including the Orange Free State (1854) and the South African Republic (1852; later the Transvaal).

The discovery of diamonds and gold in the late 1800s drew British immigrant entrepreneurs (Uitlanders, or "foreigners") into the interior, and conflict over ownership ensued. Paul KRUGER (Oom Paul), leader of the Transvaal, resisted British attempts to claim the area, including those by Cecil RHODES, prime minister of the British-controlled Cape Colony. The unsuccessful Jameson Raid, engineered by the British and intended to aid the Uitlanders in an uprising, added to the mounting tension (see JAMESON, SIR LEANDER STARR). Eventually, the SOUTH AFRICAN WAR (1899–1902) erupted between the British and the Boers, with the British the victors. In 1910 such leaders as Jan SMUTS helped create the Union of South Africa, with dominion status, out of the former British colonies and the two defeated Boer republics. Louis BOTHA became the first prime minister.

During the Depression of the 1930s, black Africans and white farmers moved to the cities to compete for unskilled jobs, and a segregationist policy was adopted by James Barry HERTZOG's government (1924–39) to preserve South Africa as a white country in which black Africans would be restricted as far as possible to reserves. The Coloured population was disenfranchised.

Many South African blacks live in segregated townships on the outskirts of white cities, such as Alexandria township near Johannesburg.

The Introduction of Apartheid. In 1948, Daniel F. MALAN's National party introduced the policy of apartheid, which was designed to ensure white supremacy. During the premiership of Hendrik F. VERWOERD, parliament adopted the Promotion of Bantu Self-Government Act, which created the legal machinery by which ten African homelands would eventually receive independence. Transkei received nominal independence in 1976, Bophuthatswana a year later, Venda in 1979, and Ciskei in 1981.

African opposition to apartheid intensified in the 1950s, spearheaded by the ANC and the Pan African Congress (PAC). These organizations were banned in 1960 following the Sharpeville massacre near Vereeniging, in which 69 Africans demonstrating against the pass laws were killed by police. In 1961 the Union of South Africa withdrew from the Commonwealth of Nations due to opposition within that body to apartheid policies, and the Republic of South Africa was declared. Opposition to apartheid at home continued and became more violent. In 1976 some 400 persons were killed when riots broke out in Soweto and other black townships.

Reform and Reaction. Under P. W. Botha, who replaced B. J. VORSTER as prime minister in 1978, the South African government began what it believed were major political and social reforms. In 1979, for example, it legalized black labor unions. The hated pass laws that had controlled the movement of blacks to the cities were scrapped in 1986, and blacks were granted limited property rights in black urban areas. The new constitution, however, continued to deny the country's black majority the right to vote in national elections and gave only limited power to Coloureds and Asians.

The reforms met with mixed reaction. Ultraconservatives within the National party defected to form two new parties—the Herstigte Nasionale party and the Conservative party. The Conservative party garnered enough votes in the 1987 parliamentary elections to replace the moderate Progressive Federal Labor party as the official opposition.

The reforms, generally viewed as an attempt by whites to share power without losing control, also largely failed to satisfy black aspirations. Elections for new black town councils with greater local authority, first held in 1983, were boycotted by about 80% of black voters. In 1984 the United Democratic Front (UDF)—a multiracial umbrella group for about 600 community, labor, student, church, and women's groups—urged Asians and Coloureds to boycott the first elections under the new constitution. Most blacks also boycotted the 1988 municipal elections, and the black-power Azanian People's Organization (AZAPO) rejected any power sharing with whites. Moderate black spokespersons such as Bishop Desmond TUTU had considerable success in persuading foreign-owned businesses operating in South Africa to disinvest, although overseas investment remained substantial.

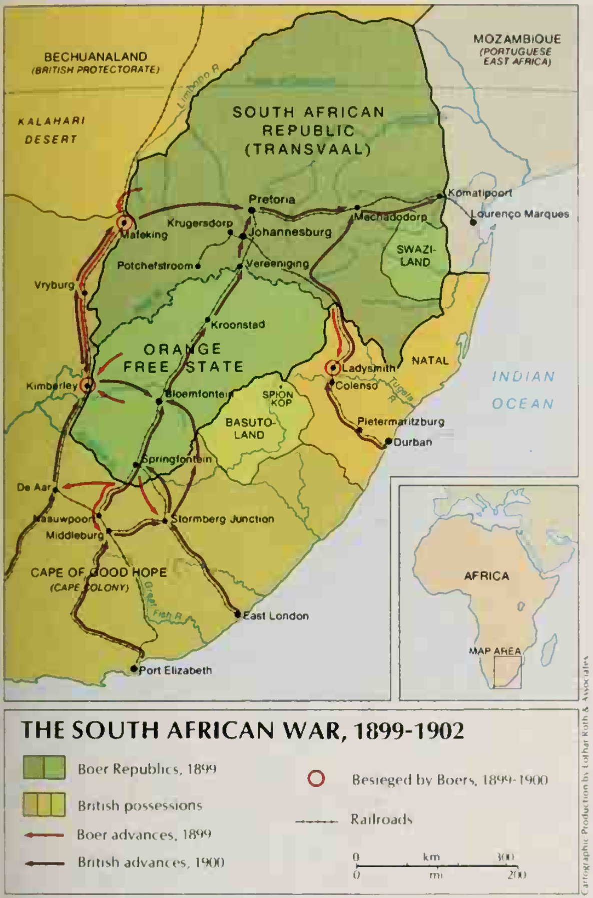
Black protests against apartheid, including rent strikes, consumer and school boycotts, demonstrations, and strikes, increased. So did violence—against the police, against blacks cooperating with the white regime, and against members of rival political and ethnolinguistic groups—particularly in the black townships. More than 2,000 people died between September 1984 and June 1986, when the government imposed a strict nationwide state of emergency.

In the September 1989 parliamentary elections, the National party lost seats to both the right and the left, but an overall majority went to candidates advocating cautious reform. Significant changes took place in 1990 and 1991. The 30-year ban on the ANC was lifted on Feb. 2, 1990, and ANC leader Nelson Mandela, the most popular leader among blacks, was released on February 11. F. W. de Klerk pledged to end apartheid, and the state of emergency was lifted in all provinces except Natal, where conflict between backers of the ANC and Zulu-based Inkatha continued. The ANC abandoned its armed struggle against the government in August. In 1991 the basic apartheid laws were repealed, the UDF was disbanded, and the government accepted a UN-supervised plan for the return of political exiles. Formal negotiations on a post-apartheid government began in December 1991 and were endorsed by white voters in March 1992. The talks broke down after a June 1992 massacre of ANC supporters in the black township of Boipatong in which South African security forces were said to be implicated. In September, after an ambush of ANC demonstrators on the Ciskei border, the government adopted measures to reduce black-on-black violence, which had claimed more than 6,500 lives since early 1990.

Foreign Affairs. South Africa signed nonaggression pacts with Swaziland (1982) and Mozambique (1984) and a cease-fire with Angola (1984), but its defense forces struck repeatedly at suspected ANC bases in Botswana, Lesotho, Mozambique, Zambia, and Zimbabwe, and it continued to wage war in Angola and Namibia against nationalist guerrillas of the South West Africa People's Organization (SWAPO). In addition, it allegedly continued its support of antigovernment guerrillas in Angola and Mozambique. In 1991, however, the dismantling of apartheid led to the lifting of many of the international sanctions earlier imposed on South Africa. The nation's relations with the rest of Africa improved after Namibia gained independence (1990) and peace accords were signed in Angola (1991) and Mozambique (1992).

South African War The South African War (1899–1902), also known as the Boer War, was a conflict between Great Britain and the two Afrikaner (Boer) governments of the South African Republic (the Transvaal) and the Orange Free State. The European settlers in both areas were mainly of Dutch ancestry and were known as Boers, or AFRIKANERS. In response to Boer pressures Britain had awarded independence to the Orange Free State in 1854. A brief revolt in 1881 restored to the Transvaal the independence it had lost to Britain in 1877. Both republics remained under British suzerainty, however.

The discovery (1886) of gold at the Witwatersrand in the Transvaal attracted a large number of European immigrants—mainly British—who built up the country's mining industry and came to control the major part of its wealth. President Paul KRUGER welcomed the economic



THE SOUTH AFRICAN WAR, 1899-1902

Cartographic Production by Lothar Roth & Associates

enterprise of these Uitlanders (foreigners) but feared the threat that they posed to the Boers' agricultural and noncommercial way of life. Anglo-Boer relations worsened because of disputes over a variety of economic issues and especially after an illegal and unsuccessful raid carried out in 1895 by British administrator Sir Leander Starr Jameson against the Transvaal in support of the Uitlanders. The Transvaal concluded an alliance with the Orange Free State and presented the British with an ultimatum protesting the reinforcement of the British garrison in South Africa.

The Afrikaners called the ensuing war the Second War of Freedom. The Boer forces laid siege to Mafeking, Kimberley, and Ladysmith, but all were eventually relieved by British troops under Lord Kitchener and Lord Roberts. In 1900 the British defeated the main Boer armies and occupied Pretoria, the Transvaal capital. In the last phase of the war (1900–02) the Boers took to guerrilla warfare, and the British retaliated by subjecting the Boer population to harsh treatment, including detention in concentration camps. The Boers were finally forced to conclude peace at Vereeniging in 1902, and the two Boer republics were reduced to British colonies.

The South African War was the largest military conflict waged in sub-Saharan Africa. The conflict was both a war of imperial supremacy and a civil war among whites; black Africans stood aloof. In Britain the excesses of the war aroused the first significant outpouring of anti-imperialist sentiment. In South Africa the war led to a rebirth of Afrikaner nationalism and to the unification of South Africa through the formation of the Union of South Africa (1910), in which the Afrikaners ultimately gained political supremacy.

South America

South America The continent of South America stretches for about 7,400 km (4,600 mi) from north to south and about 5,150 km (3,200 mi) from east to west, covering more than 17.8 million km^2 (6.8 million mi^2). It is bounded by the Atlantic Ocean on the east and the Pacific Ocean on the west. Central America and the Caribbean Sea are found to the north. The Drake Passage separates South America from Antarctica to the south. The westernmost coast is situated at about the same longitude as Miami, Fla. South America is the world's fourth largest continent—it is smaller than North America but larger than Antarctica. Offshore areas considered part of South America include Easter Island, the Falkland Islands (or Malvinas), the Galápagos Islands, and Tierra del Fuego.

South America has a number of outstanding features. The Andes, which parallel the western side of the continent, form the longest mountain chain in the world. The Amazon River surpasses all others in volume of flow, and the Amazon Basin is the world's largest area of tropical rain forest. The continent is part of Latin America, so named because most of its settlers during the colonial period came from the Iberian Peninsula. The cultural characteristics brought with these immigrants included the Spanish and Portuguese languages, the Roman Catholic religion, and a two-class social system.

The first European explorer to sight the coast of South America was Christopher Columbus, on his third voyage to the New World in 1498. The first explorer to recognize the Western Hemisphere as separate from Asia was the Italian Amerigo Vespucci, for whom the Americas are named. The 1494 Treaty of Tordesillas divided the continent into an eastern sector, in which the Portuguese could settle, and a western sector, for the Spaniards. Perhaps the most outstanding of the conquistadors was Francisco Pizarro, who overthrew the Inca empire in 1532. Argentina was the first of South America's colonies to gain independence (1810). Today South America is divided politically into 12 independent countries, 1 French overseas department, and 1 dependency.

Land and Resources

South America may be divided into eight major geomorphological provinces. Outstanding among these regions is that of the Andes, which extend for more than 6,440 km (4,000 mi) along the Pacific coast. These high, rugged mountains form a barrier to east-west travel. The highest peak in the Andes is Mount Aconcagua on the Chile-Ar-

AT A GLANCE

SOUTH AMERICA

Area: 17,804,526 km^2 (6,874,600 mi^2); 12% of the world's land area.
Population: 298,000,000 (1990 est.); 5.6% of the total world population. *Density*—16.7 persons per km^2 (43.3 per mi^2).
Coastline: 31,951 km (19,858 mi).
Elevation: *Highest*—Mount Aconcagua, 6,959 m (22,831 ft); *lowest*—Valdés Peninsula, Argentina, –40 m (–131 ft).
Northernmost Point: Point Gallinas, Colombia, 12°25' N.
Southernmost Point: Cape Horn, Chile, 56°S.
Easternmost Point: Point Coqueiros, Brazil, 34°47' W.
Westernmost Point: Point Pariñas, Peru, 81°20' W.
Principal Rivers: Amazon, Paraná-Paraguay-Plata, Orinoco.
Principal Lakes: Titicaca, Maracaibo, Poopó.
Principal Mountain Range: Andes.
Principal Deserts: Atacama, Patagonia.
Political Divisions: 12 independent countries, 1 French overseas department, 1 dependency.

gentina border, which reaches an elevation of 6,960 m (22,834 ft). The Andes serve as a drainage divide for the continent's rivers and, as part of the Pacific Ring of Fire, they are subject to a great deal of volcanic activity and frequent earthquakes. The chain of mountains is seldom more than about 320 km wide (200 mi), except in Colombia, where it splits into three distinct ranges, and in Bolivia, where it widens to about 645 km (400 mi) to accommodate the Bolivian Altiplano—a large intermontane basin lying more than 3,650 m (about 12,000 ft) above sea level. Many of the mountains are snowcapped all year. The rocks that make up the mountains contain several types of mineral ores, such as copper and tin, and precious gems, including emeralds.

Another of South America's physiographic regions is the Brazilian Shield. It comprises Precambrian crystalline rocks overlain with erosional sediments. The more resistant sand stone has been exposed to form buttes and mesas. Elsewhere, resistant diabase is associated with cuestas—elevated landforms with one side steeply scarped—over which flow a number of rivers. The Guiana Shield, located in the northern part of the continent, is essentially similar in origin, development, and character to the Brazilian Shield. Angel Falls, the highest cataract in the world, lies within the Guiana Shield.

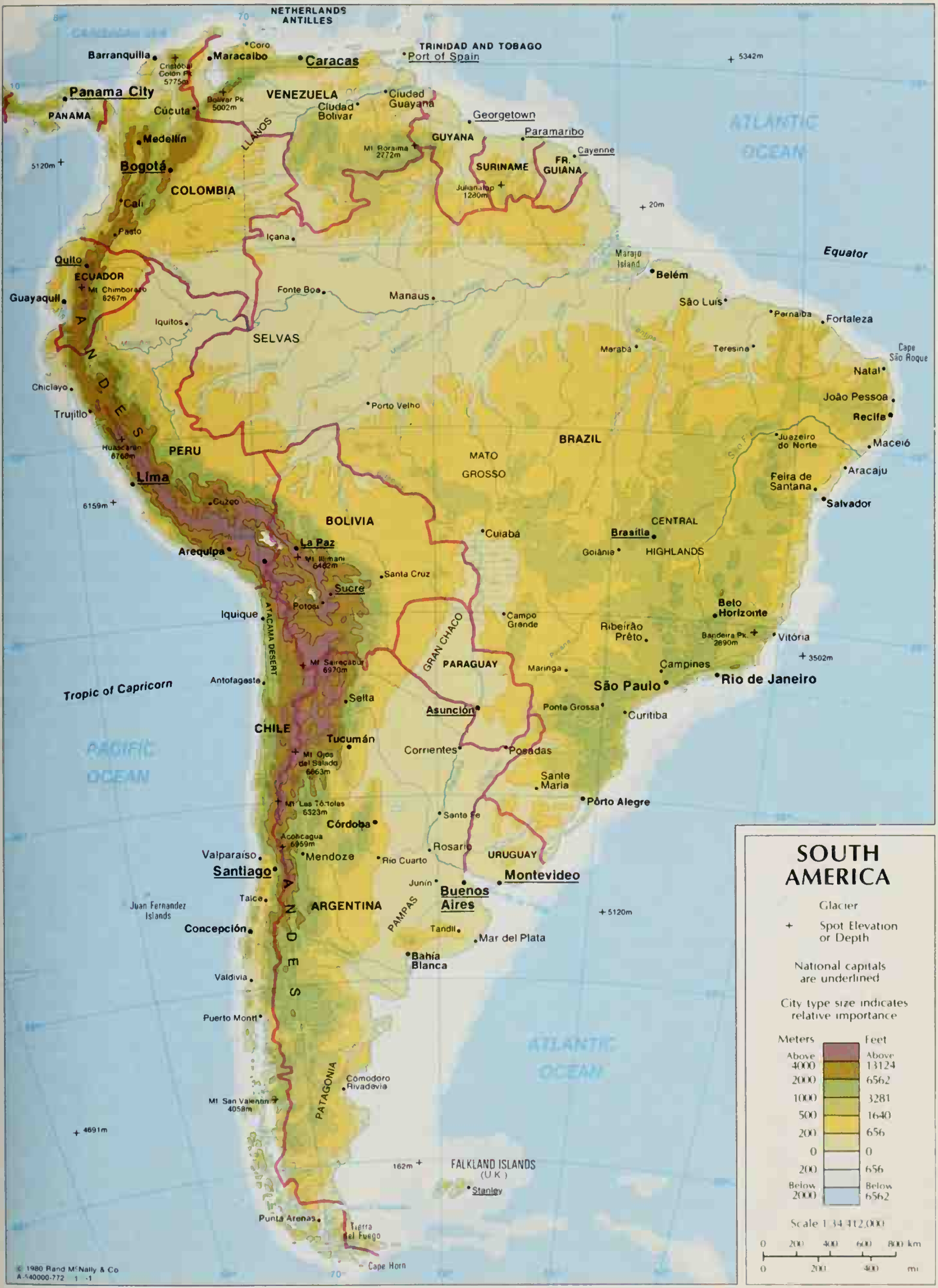
Two South American landform regions can be classified as either highland or lowland. One of these is the Paraná Plateau, often considered part of the Brazilian Shield. Named for the river that slices through it, the Paraná Plateau resulted from a long series of lava flows. The second marginal region is the low Patagonian Plateau (or high Patagonian Plain). An ancient massif, Patagonia was first covered by sediments and then eroded by streams flowing eastward from the Andes.

As for lowlands, South America has narrow coastal plains, but the Amazon Basin is the largest of the continent's landform provinces, covering about 7 million km^2 (2.7 million mi^2). The Amazon Basin is widest near the Andes and narrowest near the mouth of the Amazon River.

The Orinoco Plain is separated from the Amazon Basin by a low interfluve. Like the Amazon Basin, it is named for and is a product of the major river that flows across it. The last of the lowlands is the Paraná-Paraguay-Plata Plain, where an ancient rocky surface has been covered by alluvium; only a few peaks of the original surface protrude. Those lowland areas are frequently associated with sizable deposits of petroleum.

South America has few good harbors. The best is probably that of Rio de Janeiro. Although others may have protected anchorages, their harbors are often shallow and must be continually dredged to permit access for oceangoing vessels.

SOUTH AMERICA



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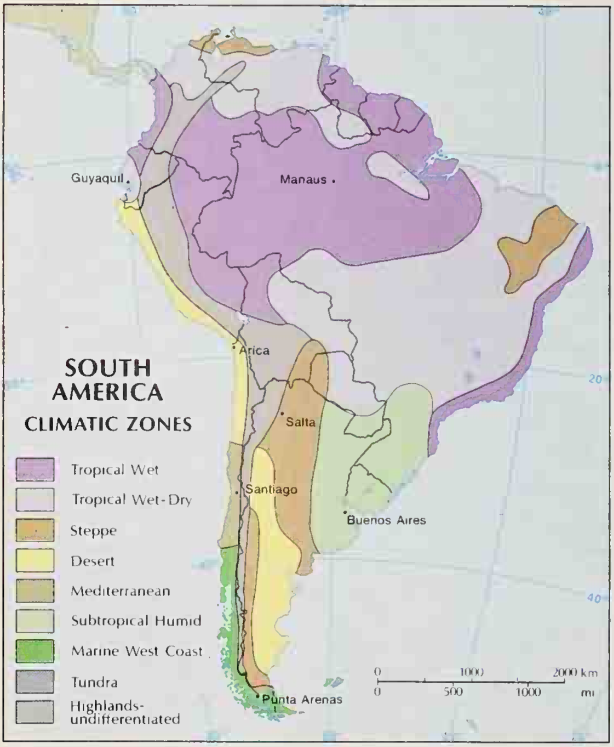
Climate. Many factors affect the climate of South America. Latitude is the most significant of these. Tropicality is the dominant feature of South America's climate, and much of the continent remains frost free throughout the year. Altitude is a second factor, moderating the hot, tropical temperatures. The ocean's proximity—in combination with prevailing winds—affects the amounts and distribution of rainfall. Several coastal areas receive in excess of 2,540 mm (100 in) of rainfall annually; these are the southeast coast of Brazil, the region from Guyana to the mouth of the Amazon, the Pacific coast of Colombia, and southern Chile. The Amazon Basin also receives abundant precipitation. In contrast, no rainfall has ever been recorded at Calama, Chile, in the Atacama Desert. Finally, human habitation has altered the climate, especially in urban regions where air pollution has increased both temperatures and the amounts of precipitation.

Seven major climate types are found in South America. Most of the Amazon Basin and coastal regions, where onshore winds blow for much of the year, have a tropical rainy climate. Arid and semiarid climates dominate the coast of Peru and northern Chile. Aridity also characterizes a small area in northeast Brazil and a diagonal strip crossing Argentina from northwest to southeast. Wide temperature extremes, low rainfall, and unreliable precipitation typify these dry regions. The principal characteristic of the tropical wet and dry climate covering most of Brazil and the Orinoco River basin is an alternating precipitation regime: six months of summer rain followed by six months of winter drought.

The snow-capped cone of Cotopaxi, the highest active volcano in Ecuador, towers to a height of 5,897 m (19,347 ft) above sea level in the Andes.



The Mediterranean climate of central Chile also experiences alternating periods of rain and drought—but there the rainfall comes during the winter. In contrast, the temperate marine climate of southern Chile is cool, rainy, and windy throughout the year. The humid subtropical climate of southern Brazil, Uruguay, Paraguay, and northeastern Argentina is similar to that of the U.S. state of Georgia. Finally, South America's mountain regions experience considerable variation in rainfall and temperature.

Drainage. South America's longest river is the Amazon. Originating in the Peruvian Andes, the Amazon flows approximately 6,450 km (4,000 mi) to its mouth in the Atlantic—it is the world's second longest river. No other river approaches its volume of flow, which exceeds that of the world's 10 next largest rivers combined. Oceangoing ships can navigate almost 1,600 km (1,000 mi) upstream.

The next largest river system in South America is that of the Paraná, Paraguay, and Uruguay rivers, the waters from which empty into the Plata estuary. The Paraná River is navigable for oceangoing vessels as far upstream as Rosario, Argentina. Boats regularly travel upstream on the Paraguay River to Corumbá, Brazil. A large combined bridge and dam completed in 1981 at Salto Grande marks the head of navigation on the Uruguay River. Other navigable rivers in South America include the Magdalena River in Colombia, the Orinoco River in Venezuela, and the São Francisco River in eastern Brazil.

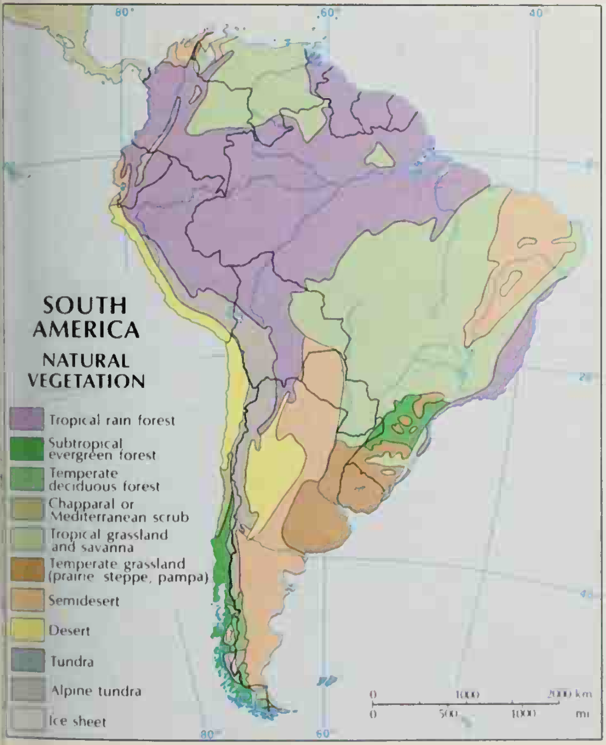
South America has few sizable lakes. Lake Titicaca—although not the largest—is the highest navigable body of water in the world. The elevation of its surface is 3,810 m (12,500 ft) above sea level. Lake Titicaca is shared by the countries of Peru and Bolivia. Lake MARACAIBO, in Venezuela, the largest body of water in South America, is connected to the Caribbean Sea by a narrow inlet. Maracaibo is mostly freshwater, shallow, and punctuated by petroleum derricks. More picturesque is the Andean Lake District of Argentina and Chile.

Vegetation. The rainiest parts of tropical South America are covered with tropical rain forest, or selva. The biological diversity of the Amazonian selva is now threatened by deforestation resulting from road construction, lumbering, and new rural settlement. Tropical hardwood trees such as mahogany are especially prized. The trees experience no dormant period, and many species are so dense that they do not float. Their interlocking crowns form a canopy that blocks most sunlight. Where sunlight reaches the forest floor, jungle results.

In southern Brazil and in central and southern Chile, mid-latitude forests with mixed stands of trees are common. South America as a whole is seriously short of softwood lumber, which many countries are forced to import.

Tropical scrub woodlands cover large areas in northeastern Brazil, western Paraguay, and northern Argentina. Dense tangles of thorny bushes are common in the interior of northeast Brazil. The quebracho (literally, "break-ax") of Paraguay and Argentina is a source of tannin for leather processing. Regions with a summer rainy season are normally associated with savanna vegetation. Such areas are generally used for cattle ranching. In the PAMPAS and other parts of northeastern Argentina, in Uruguay, and in the far south of Brazil, prairie grasslands have been extensively modified by human action.

The Iguaçu Falls are located on the border between Argentina and Brazil a short distance upstream from the confluence of the Iguaçu and Paraná rivers.

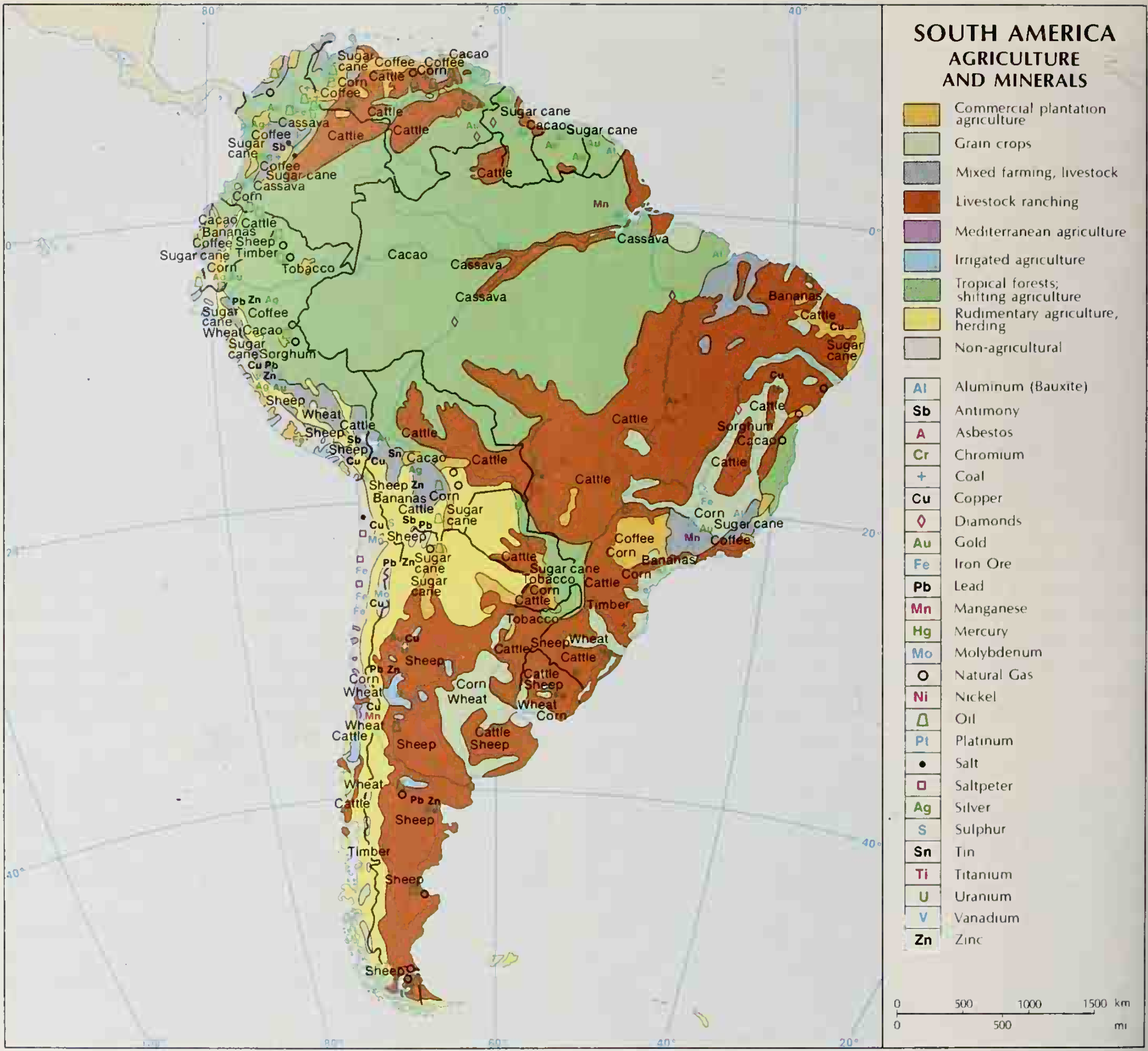

SOUTH AMERICA
NATURAL VEGETATION
Tropical rain forest
Subtropical evergreen forest
Temperate deciduous forest
Chapparal or Mediterranean scrub
Tropical grassland and savanna
Temperate grassland (prairie steppe, pampa)
Semidesert
Desert
Tundra
Alpine tundra
Ice sheet
80°
60°
40
80°
60°
0
1000
2000 km
0
500
1000
mi

Desert shrub vegetation is related to arid climates, whereas in the mountains plants are arranged into zones based on elevation. In sequence from low to higher elevations, these zones are known as the *tierra caliente* (or zone of tropical crops), *tierra templada* (zone of coffee), *tierra fría* (zone of grains), the zone of uncleared forest, and the zone of alpine meadows.

Fauna. The South American continent offers a tremendous variety of wildlife, although some species are now endangered. In the rain forest, monkeys and parrots are declining as they fall prey to hunters. The chinchilla is native to the continent. The electric eel and the flesh-eating piranha can be found in South American waters.

One of the most distinctive animals of the South American tropical forest and grassland is the tapir, a hoglike creature standing higher than 1 m (40 in) at the shoulders. Equally distinctive is the rhea, a relative of the ostrich, which inhabits the mid-latitude grasslands of Argentina. An endangered species is the condor, which nests along the Pacific coast. In the Andes Mountains, Indians have domesticated llamas for use as beasts of burden and guinea pigs for food. Other animals found only in South America are the anaconda, the capybara, the giant otter, and the spectacled bear.

The Galápagos Islands, about 965 km (600 mi) west of Ecuador, contain many species of animals found nowhere else on Earth. The naturalist Charles Darwin visited the islands in 1835, studying such life forms as the flightless cormorant, the giant land tortoise, and the marine iguana.



Mineral Resources. South America's mineral resources have often been described as superlative but poorly matched. For example, Brazil and Chile both have massive deposits of iron ore but lack the good-quality coking coal needed to convert it to steel. Recent discoveries of iron ore may eventually give Brazil the world's second largest proven reserves, after the USSR. Venezuela has the continent's second largest production of iron ore. Brazil also has sizable deposits of manganese and bauxite, and Colombia has become a major exporter of coal. Bolivia has long been among the world's leading tin exporters.

(Right) *A gaucho ropes a calf near Tornquist, a town on the pampas, or plains, of Argentina. Argentina's economy traditionally has been dominated by the export of meat, hides, and various animal by-products.*

The Catavi tin mine in west central Bolivia is one of the largest in the world. For many years Bolivia was a leading world producer of tin, but low world prices during the 1980s led to a sharp decline in production.

Chile also usually leads world nations in annual copper production; Peru is South America's second most important producer of copper.

South America's energy resources have gained increased attention in recent years. In this regard Venezuela reigns supreme because of its petroleum deposits. Ecuador, Argentina, Peru, and Bolivia have more modest—but not unimportant—oil resources.

Arable Land. Brazil has the largest amount of arable land of any South American nation—more than 300,000 km^2 (115,830 mi^2), or almost 40% of the continent's total. Argentina ranks second, with about 214,400 km^2 (82,800 mi^2). Although no other countries in South America have as much arable land, both of these nations suffer from handicaps. Much of the soil in the tropical parts of Brazil is low in fertility, whereas a great deal of Argentina is arid or semiarid.

People

South America's racial heritage stems from three basic sources: Caucasian, African, and Indian. The Indians, who arrived perhaps 11,000 to 14,000 years ago, were at first hunters and gatherers. Many groups took up agriculture about 5,000 years ago. Three major groups settled in and around the Andes: the CHIBCHA in the north; the Indians subjugated by the Incas in the area of present-day Peru; and the ARAUCANIANS to the south. Other groups settled along the shores of the Caribbean, in the tropical rain forests, and on the eastern margins of the continent. All these Indians together are thought to have numbered about 14 million in the year 1500.

The Europeans arrived in the 1500s, enslaved the Indians, and forced them to work in mines and on plantations. At the same time, European missionaries were converting the Indians to Christianity. The distribution of Indians influenced the direction of the Spanish colonial effort more than any other factor. Although large numbers of Indians died of mistreatment or exposure to European diseases, millions of their descendants survive. Indian women intermarried with the European conquerors, and from these unions a new race was born—the mestizo or *mameluco* (the word used in Brazil).

Because of labor shortages, the Europeans imported thousands of black slaves from Africa, the largest number to Brazil and Colombia. They also intermarried with their masters, creating a new racial type known as the mulatto. The first pronouncement against slavery on the continent was British Guiana's Emancipation Act of 1833. The process was completed with Brazil's abolition of slavery in 1888.

South America's ethnic composition has been further modified by the arrival of large numbers of Europeans

Cartagena, an important Caribbean port in northern Colombia, is the capital of Bolívar department. Founded and fortified by conquistadors during the 16th century, Cartagena contains some of the most extensive surviving examples of Spanish architecture in the Western Hemisphere.

The Teatro Colón of Buenos Aires is one of the most sophisticated cultural facilities in South America. The theater houses the Argentinian National Symphony Orchestra as well as its own ballet and opera companies.

who have immigrated since 1850. The Japanese are among the more recent arrivals.

Today, Indians are concentrated in the Andean Highlands (especially in Peru, Bolivia, and Ecuador) and in the wet tropical lowlands; Argentina, Uruguay, and southern Brazil are inhabited primarily by pure Caucasians; blacks and mulattoes are dominant in several parts of Brazil and Colombia; elsewhere, mestizos are in the majority.

Spanish is the official language of nine countries in South America. In Brazil, Portuguese is spoken. English and Dutch are used in Guyana and Suriname, respectively. French is the language of French Guiana. Many Indians are monolingual, speaking only their aboriginal languages. As many as 82 different Indian language groups have been identified.

Roman Catholicism is found throughout South America; only Guyana is predominantly Protestant. Argentina has the largest Jewish population, estimated at about 300,000 (1988).

Education and Health. Argentina, Chile, Guyana, and Uruguay each has a literacy rate of 90% or greater. Much further down the scale is Bolivia, where about 25% of the population was estimated to be illiterate in 1988.

Bolivia, Ecuador, Peru, Guyana, and Colombia fail to supply their people with adequate diets in terms of caloric and protein intakes. The leading causes of death by country are dysentery (especially in Colombia), tuberculosis (Peru), whooping cough (Bolivia, Ecuador, and Peru), and measles (Ecuador, Bolivia, and Colombia). In South America leading causes of morbidity among reportable diseases are syphilis and typhoid fever. Infant mortality rates are exceptionally high in some South American countries despite continuing medical progress. For example, more than 110 of every 1,000 Bolivian infants under the age of 1 died in 1988. In the more developed nations, though, life expectancy exceeds 70 years.

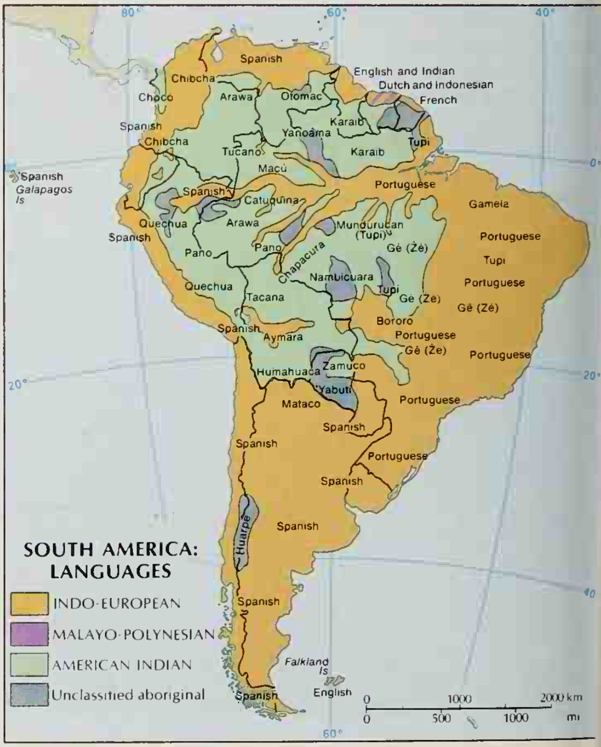
Demography. The population of tropical South American countries is increasing rapidly. In 1988 their rate of natural increase exceeded 2.2% a year, comparable to that of Mexico and Central America, but lower than that of Africa. Paraguay and Ecuador had the highest growth rates (2.9% and 2.8%, respectively). The temperate-climate nations of Argentina, Chile, and Uruguay, however, had a combined growth rate of just 1.5% in 1988, below the world average of 1.7%.

The population is unevenly distributed in South America. Most of the people live in clusters around the periphery of the continent—a reflection of its early role as a supplier of raw materials to the European nations. South America's most densely populated country is Ecuador, with 37 persons per km^2 (93 per mi^2).

Urbanization has brought about a significant redistribution of people and has resulted in the rapid growth of South American cities in the past several decades. Argentina, Uruguay, and Chile are all close to 85% urban. Brazil's cities are growing at an annual rate of approximately 5%.

Economic Development and Commerce

South America has not fully entered the age of industrialization. Suriname had South America's highest per capita gross national product (GNP) in 1989, at $3,020, followed by Uruguay ($2,620), Brazil ($2,550), and Venezuela ($2,450). Much of Venezuela's wealth comes from its petroleum exports, and income there is unevenly dis-



The twin towers of the Simón Bolívar Center, which house government offices and a major shopping center, rise above Caracas, the Venezuelan capital.

tributed; Argentina's economy is much more balanced. In terms of total GNP, Brazil ranks first, with $375.1 billion in 1989; Guyana is last, with only $248 million.

An important aspect of the general South American economy in the 1980s was mounting foreign debt, a result of recession, inflation, and trade imbalances. By 1988, Brazil had a total foreign debt of $121 billion; Argentina owed $55 billion. The debt crisis continued through the 1980s, although individual countries imposed austerity measures and international cooperation increased.

Agriculture. South American countries have been known for their agricultural exports. Brazil has long been the world's leading exporter of coffee, as well as a top producer of sugarcane and cacao. Bananas are the principal crop of Ecuador, which exports a significant percentage of the world's total.

Argentina and Brazil are widely known for their beef cattle. About 93 million head roam the pastures of Brazil, whereas Argentine pastures support close to 53.7 million head (mid-1980s ests.). Uruguay ranks second behind Argentina in numbers of sheep, but its ratio of sheep per person (7.08) is the highest in the world. Pigs are raised throughout South America.

The most important grain crops are maize, rice, and wheat. South Americans supplement these foods with root crops such as cassava and potatoes. South American farmers generally have kept ahead of the baby boom, as per-capita food harvests continue to increase.

Forestry and Fishing. Although short of softwood lumber, South America's forests are the source of innumerable by-products. Among these are quinine (from the bark of the cinchona tree), eucalyptol (a cough-drop ingredient taken from the eucalyptus tree), rubber, chicle (chewing-gum base), coconuts, tannin (for leather curing), and palm oil (squeezed from the tree's nuts and used to make soap and cosmetics). Brazil is the leading exporter of forest products.

Peru is exploiting one of South America's major biological resources—the anchovy—just off its coast. Peruvian fishermen caught enough anchovies during the 1960s to propel their country into first place in the world for volume of fish caught, but catches declined during the 1970s and '80s.

Transportation. The most industrialized countries have the most highly developed land transportation facilities. Argentina, Brazil, and Chile have by far the longest rail networks. These same three countries also have more lengthy paved and gravel road systems than any other nation in South America. Brazil, Argentina, Venezuela, and Colombia are able to supplement their railroads and highways with important inland waterways. The airplane is particularly important in maintaining communications in the rugged Andean countries.

Trade. The nations of South America have joined with some neighboring countries to the north to form the Latin American Integration Association. Its purposes are to encourage intraregional trade and create a common tariff wall.

Exports have diversified somewhat in recent decades. The worldwide oil glut of the mid-1980s reduced income from the still important petroleum exports. The ten leading export commodities are: oil, coffee, iron ore, soybeans, copper, beef, maize, bananas, cacao, and cotton. The United States is the leading trade partner for both imports and exports for almost every South American country. The balance of trade during most of the 1970s was unfavorable to South America as a whole; during the 1980s, however, the region experienced an upswing in exports. Some countries manage to use tourism (along with loans and foreign capital investments) to balance their budgets. Argentina, Brazil, Colombia, Peru, Uruguay, and Venezuela in particular have attracted many tourists.

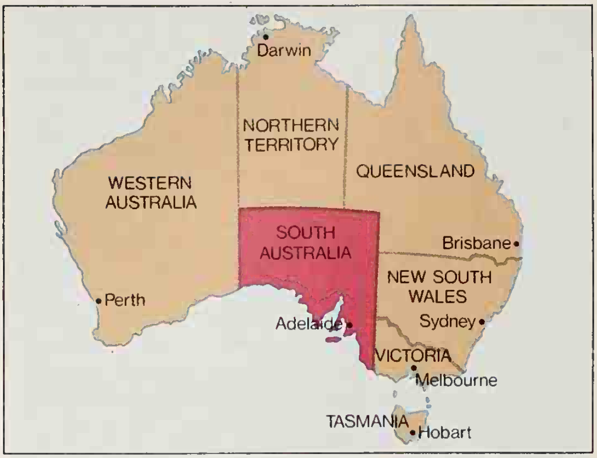
Energy. Petroleum is one of South America's principal sources of power. The only net exporters of oil, however, are Venezuela, Ecuador, Peru, Argentina, and Bolivia.

South America is estimated to have 17.3% of the world's potential water power. Of this amount, Brazil has the largest share. The Brazilians inaugurated Itaipú, the largest hydroelectric installation in the world, in 1984. The neighboring country of Paraguay—a partner with Brazil in major hydroelectric projects—is one of the world's leading exporters of electricity.

South Australia

The state of South Australia, located in the south central part of Australia, covers 984,377 km^2 (380,069 mi^2). It occupies about one-eighth of the continent and has a population of 1,373,100 (1986 est.). The capital is ADELAIDE.

Underlain by a crystalline shield in the west and sedimentary basins elsewhere, South Australia's topography is low and mostly flat; more than 80% of the land is less than 300 m (1,000 ft) in elevation. The northeast is part of the Great Artesian Basin, the world's largest region of natural springs.



South Australia's population is predominantly of British ancestry. The largest religious denomination is the Anglican church, followed by the Roman Catholic and Methodist churches. South Australia grew faster than Australia as a whole until the mid-1960s, when rising unemployment reversed the trend. Almost 85% of the population live in cities, primarily Adelaide.

A part of the labor force is engaged in primary production, including mining and quarrying. The state's Middleback Range is a major producer of iron ore, and South Australia is a major world source of opals. Large natural-gas fields supply much of Australia's energy requirements. The automotive industry employs about 20% of the labor force. Other industries manufacture metal products, chemicals, and textiles. The two major sources of export revenue are sheep and wheat; of secondary importance are fruits and vegetables, which are produced from irrigated farms and vineyards.

Matthew Flinders explored the South Australian coast in 1802, but permanent settlement did not begin until 1836. Unlike other parts of the continent, South Australia was never a penal colony. The population increased rapidly during the mid-1800s as disappointed gold miners from Victoria and New South Wales migrated to South Australia to raise sheep and grow wheat. South Australia became a state in 1901. Recurring droughts have led to periodic economic depressions in inland areas.

South Bend South Bend (1990 pop., 105,511), the seat of Saint Joseph County, lies on the Saint Joseph River in northern Indiana, about 130 km (80 mi) east of Chicago. Surrounded by farmlands, South Bend is a processing and shipping center; it also manufactures farm and electrical machinery, transportation equipment, paints, and plastic products. The city was settled in the 1820s.

South Carolina South Carolina, the Palmetto State, was one of the original 13 U.S. states. Located on the Atlantic coast, it is bounded by North Carolina on the north and Georgia on the southwest. One of the smaller states, it ranks 40th in land area but 25th in population. The capital is Columbia, located in the geographic center of the state. The state's name is derived from Charles I of England, who granted "Carolina" in 1629 to Sir Robert Heath. The first permanent European settlement was at Charles Town—renamed Charleston in 1783—in early 1670. South Carolina assumed a position of political and social leadership during the colonial, revolutionary, and antebellum periods. The post–Civil War era and the early 20th century witnessed a severe social and economic decline in the state, but the rise of the New South in the last few decades has renewed the state's vitality.

Land and Resources

South Carolina can be divided into three physiographic regions. The Coastal Plain extends from the Sea Islands inland to the Sand Hills. The topography is flat near the coast but more rolling in the interior. Sandy barrier islands and salt marshes, covered by salt-marsh grass and black needle rush, constitute the common coastal environment. Old beach ridges are covered with maritime forests of palmetto (the state tree), live oak, loblolly pine, and wax myrtle. In the outer Coastal Plain, especially along rivers, numerous swamps support bald cypress, swamp tupelo, water oak, and willow trees. A physiographic feature unique to the plain are the many Carolina Bays. These elliptical bogs or lakes are bordered, predominately on the eastern quadrant, by a sand rim. Characteristic vegetation includes sweet and red bay (for which the feature is named), cypress, loblolly pine, and sweet gum. The Coastal Plain culminates in the Sand Hills, which extend from Aiken northeastward through Columbia to Cheraw. The sandy soils of these hills support scrub oak, blackjack oak, and longleaf pine.

The PIEDMONT rises from the FALL LINE, which marks the boundary with the Coastal Plain, to an elevation of about 427 m (1,401 ft). Streams have cut deeply into the surface and left a rolling-to-hilly topography. Severe-to-moderate erosion, which followed extensive agricultural clearing, removed much of the topsoil and left the heavy red-clay subsoil now characteristic of the region. Native vegetation is basically hardwood: black, white, and red oak; pignut hickory; and dogwood. Shortleaf pine also grows in the Piedmont. Along streams cottonwood, yellow poplar, willow, sycamore, and sweet gum are common. The loblolly pine, which is not native to the Piedmont, has been widely planted for pulpwood.

The BLUE RIDGE MOUNTAINS occupy a small portion of the northwest corner of the state. Elevations vary from 427 m (1,401 ft) to 1,085 m (3,560 ft) at Sassafras Mountain, the highest point in South Carolina. The thin, well-drained soils of the steep slopes are clayey to loamy.

Drainage. Cutting across the physiographic provinces, which rise in elevation northwestward from the coast, are the southeastward-flowing river systems, including the Savannah, Black, Edisto, Pee Dee, and Santee. The most extensive drainage basin is that of the Santee and its tributaries. The state's largest lakes are Clark Hill and Hartwell reservoirs and Lakes Marion, Moultrie, and Murray.

AT A GLANCE

SOUTH CAROLINA

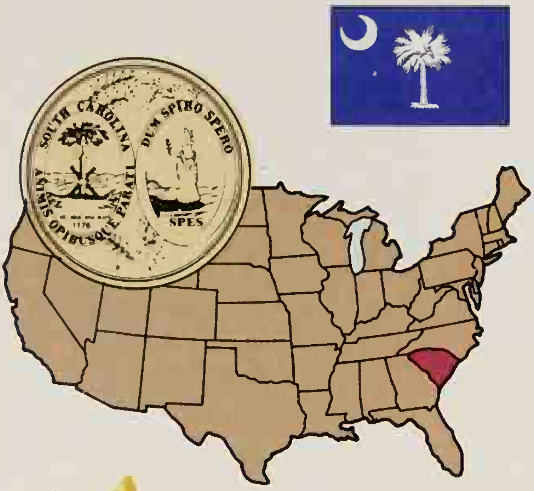
Land: Area: 82,898 km^2 (32,007 mi^2); rank: 40th. Capital and largest city: Columbia (1990 pop., 98,052). Counties: 46. Elevations: highest—1,085 m (3,560 ft), at Sassafras Mountain; lowest—sea level, Atlantic coast.

People: Population (1990): 3,505,707; rank: 25th; density: 44.7 persons per km^2 (115.8 per mi^2). Distribution (1990): 54.6% urban, 45.4% rural. Average annual change (1980–90): +1.2%.

Government (1993): Governor: Carroll A. Campbell, Jr., Republican. U.S. Congress: Senate—1 Democrat, 1 Republican; House—3 Democrats, 3 Republicans. Electoral college votes: 8. State legislature: 46 senators, 124 representatives.

Economy: State personal income (1989): $47.9 billion; rank: 27th. Median family income (1989): $30,797; rank: 37th. Agriculture: income (1989)—$1.2 billion. Fishing: value (1989)—$25 million. Lumber production (1991): 1.3 billion board feet. Mining (nonfuel): value (1988)—$358 million. Manufacturing: value added (1987)—$19.1 billion. Services: value (1987)—$9.4 billion.

Miscellany: Statehood: May 23, 1788; the 8th state. Nickname: Palmetto State; tree: palmetto; mottoes: *Animis Opibusque Parati* ("Prepared in Mind and Resources") and *Dum spiro spero* ("While I breathe, I hope"); songs: "Carolina" and "South Carolina on My Mind."



Yellow jasmine

Carolina wren

Climate. Average temperatures in January vary from 11° C (51° F) in Charleston to 7° C (44° F) in Greenville-Spartanburg. July averages are 26° C (79° F) in Greenville-Spartanburg and 28° C (82° F) in Charleston. The mean annual precipitation throughout the state totals 1,295 mm (51 in). Hurricanes occasionally threaten the coast.

Animal Life. The abundance of white-tailed deer permits a long hunting season. Fox, mink, muskrat, opossum, otter, rabbit, raccoon, skunk, and squirrel are protected species in South Carolina. Duck, geese, quail, and wild turkey attract hunters, and a wide variety of freshwater and saltwater fish is found in South Carolina's waters.

Resources. Forests cover more than 60% of South Carolina. Major resources are limestone, sand, and gravel in the Coastal Plain, kaolin or china clay mined principally in Aiken County, granite in the Piedmont, and various clays for brick and tile mined in many areas. Other minerals include vermiculite, kyanite, and sericite. Petroleum deposits may lie off the South Carolina coast. Many rivers provide hydroelectric power.

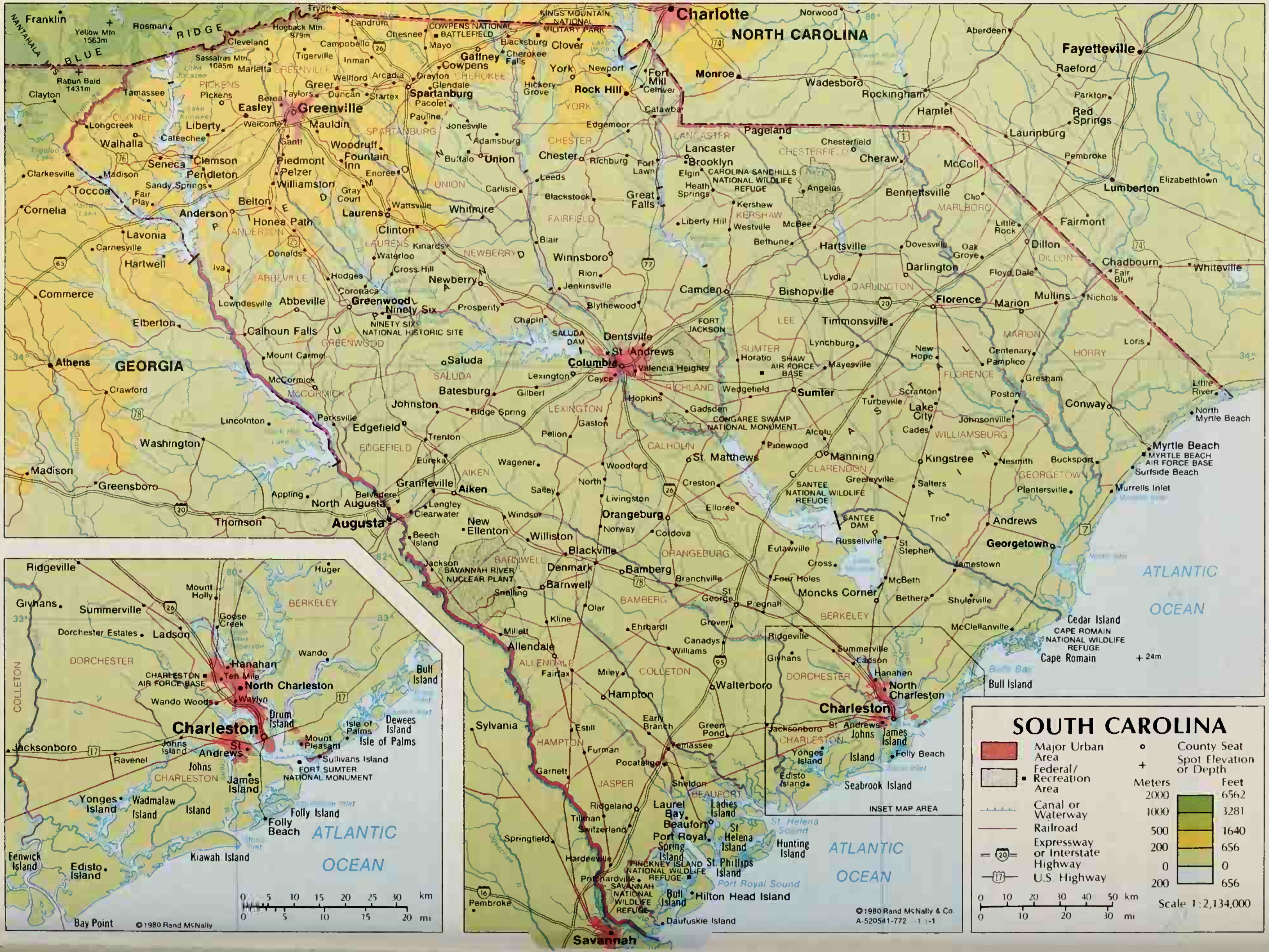
People

About 31% of South Carolina's population are nonwhite—one of the highest percentages in the nation. Most of the state's nonwhites are black. About 46% of the population live in the areas of CHARLESTON, GREENVILLE, SPARTANBURG, and COLUMBIA. Major growth continues in those areas and along the northeastern coast.

South Carolina's growth rate through the 20th century has lagged behind that of the United States as a whole. This resulted from net out-migration, which characterized the state until the 1970s. From 1970 to 1980, however, the state's population increased by more than 20%, almost twice the national average of 11.4%. The growth rate during the 1980s was 12.3%, compared to the national average of 10.2%. The largest religious group is the Southern Baptists. Methodists and Presbyterians form the other major denominations in the state.

Education. Public education did not begin in South Carolina until ratification of the 1895 constitution, which provided for the allocation of school funds and establishment of a state board of education. During the 1970s significant improvements were made in public education. South Carolina's institutions of higher education include Furman University (1826) and Bob Jones University (1927), both in Greenville, and several state institutions, including the University of South Carolina (1801) at Columbia and Clemson University (1889) at Clemson.

Cultural and Historical Sites. Major museums in South Carolina include Gibbes Art Gallery in Charleston, the Columbia Museum of Art and Science, and the religious art collection at Bob Jones University in Greenville. The


SOUTH CAROLINA
Major Urban Area
Federal/ Recreation Area
Canal or Waterway
Railroad
Expressway or Interstate Highway
U.S. Highway
County Seat
Spot Elevation or Depth
Meters
2000
1000
500
200
0
200
Feet
6562
3281
1640
656
0
656
0 10 20 30 40 50 km
0 10 20 30 mi
Scale 1:2,134,000
©1980 Rand McNally & Co.
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INSET MAP AREA
NORTH CAROLINA
GEORGIA
ATLANTIC OCEAN
BLUE RIDGE
Charlotte
Fayetteville
Lumberton
Monroe
Wadesboro
Rockingham
Laurinburg
Rock Hill
Greenville
Spartanburg
Anderson
Columbia
Florence
Sumter
Orangeburg
Aiken
Augusta
Charleston
North Charleston
Myrtle Beach
Conway
Georgetown
Beaufort
Hilton Head Island
Savannah
Athens
Camden
Darlington
Marion
Dillon
Kingstree
Manning
Walterboro
Hampton
Allendale
Barnwell
Bamberg
Greenwood
Abbeville
Newberry
Laurens
Union
Chester
Lancaster
Cheraw
Bennettsville
Bishopville
Hartsville
Winnsboro
Edgefield
Saluda
Lexington
St. Matthews
Moncks Corner
Clemson
Seneca
Walhalla
Easley
Pickens
Gaffney
York
Fort Mill
SALUDA DAM
SANTEE DAM
FORT JACKSON
SHAW AIR FORCE BASE
MYRTLE BEACH AIR FORCE BASE
CONGAREE SWAMP NATIONAL MONUMENT
CAROLINA SANDHILLS NATIONAL WILDLIFE REFUGE
SANTEE NATIONAL WILDLIFE REFUGE
CAPE ROMAIN NATIONAL WILDLIFE REFUGE
SAVANNAH NATIONAL WILDLIFE REFUGE
PINCKNEY ISLAND NATIONAL WILDLIFE REFUGE
SAVANNAH RIVER NUCLEAR PLANT
NINETY SIX NATIONAL HISTORIC SITE
COWPENS NATIONAL BATTLEFIELD
KINGS MOUNTAIN NATIONAL MILITARY PARK
FORT SUMTER NATIONAL MONUMENT
CHARLESTON AIR FORCE BASE
Cape Romain
Bull Island
Kiawah Island
Folly Beach
Isle of Palms
Sullivans Island
Mount Pleasant
Summerville
Hanahan
Goose Creek
Ladson
Dorchester Estates
Sassafras Mtn 1085m
Rabun Bald 1431m
Yellow Mtn 1563m
Hogback Mtn 979m
©1980 Rand McNally

Charleston Museum (established 1773) is the oldest public museum in the United States.

National and state historical parks include FORT SUMTER, where the Civil War began, and Kings Mountain National Military Park. Popular resorts are located along the Atlantic coast, especially on the section known as the Grand Strand (near Myrtle Beach), on the offshore Sea Islands, and in the mountains.

Communications. A leading state newspaper is the *Charleston News and Courier* (founded 1803). The South Carolina Educational Radio Network has won national broadcasting awards, and the state's educational television system is highly regarded.

Economic Activity

South Carolina's economy traditionally has been based on agriculture, principally rice and cotton. Recently, however, manufacturing has been increasing in importance. Imaginative tax legislation, the work of the State Development Board, and the passage of a right-to-work law in 1954 has created an amenable environment for industry.

Manufacturing. South Carolina's principal industry is textiles. Most textile mills are located in the northwestern part of the state. The industry has been hurt in recent years by foreign competition, however, creating a situation that has brought about some manufacturing diversification in the state. Other leading industries include chemicals, nonelectrical machinery, paper and paper products, and food and food products.

Agriculture. South Carolina's major agricultural commodities are tobacco, soybeans, dairy products, and corn. Cotton, traditionally a leading crop, is still valuable, as are wheat, peaches, and livestock. Major commercial fishing species are various saltwater fish and shellfish. About two-thirds of the state is covered by forests, most of which are classified as commercial timberland.

Mining. South Carolina has a small mining industry, producing only nonfuel minerals. It is a leading producer of vermiculite and mica (scrap). Other commercial minerals are kaolin (and other types of clays), cement, stone, and sand.

Energy. South Carolina's energy sources include nuclear power plants; coal, oil, and gas-burning plants; and hydroelectric plants. Large hydroelectric installations include the Santee-Cooper project and the Lake Murray dam. A large nuclear reprocessing and storage plant is located on the Savannah River.

Tourism. Tourism is an increasingly important industry in the state. More than three-fourths of the vacation spending is at Charleston and the resorts of Myrtle Beach and Hilton Head Island. Other major attractions are the Cowpens National Battlefield and Fort Sumter and Kings Mountain military sites.

Transportation. Interstate highways in South Carolina include I-26, which crosses the state in a northwest-southeast direction, and I-95, running north and south. Railroad facilities include freight service, provided by Southern Railway and Seaboard System Railroad, and limited Amtrak passenger service. The major port is at Charleston, and the Atlantic Intracoastal Waterway is a major inland thoroughfare. International airports are at Charleston, Columbia, and Greenville-Spartanburg.

To the southeast in South Carolina's Piedmont region is Columbia, the state's largest city. The site was chosen as the state capital in 1786 because of its location between the coastal lowlands and the mountains.

Government

South Carolina state government, based on the 1895 constitution, has three branches. Legislative authority rests with the general assembly, composed of the house of representatives and the senate. The 124 representatives serve 2-year terms and are elected from districts based on population. The 46 senators serve staggered 4-year terms. The executive branch includes the governor, the lieutenant governor, and seven constitutional officers; each serves a 4-year term. Judicial authority is vested in the supreme court, composed of the chief justice and four associate justices. The justices, elected by the legislature, serve staggered 10-year terms. The legislative branch wields the greatest power, controlling appropriations, finances, and appointments to the state courts and to boards, commissions, and agencies. The governor is a virtual figurehead, who can do no more than persuade the legislature. The county is the unit of local government.

For many decades following RECONSTRUCTION, South Carolina was staunchly Democratic. Since 1960, however, the state has voted Republican in every national election except that of 1976.

History

About 25 or 30 distinct native tribes lived in South Carolina at the time of first European contact. The major groups were the CHEROKEE, the CATAWBA, and the YAMASEE. By 1800 virtually all had been driven from the state.

Francisco Gordillo was the first European to visit South Carolina in 1521. The Spanish attempted the first European settlement near present-day Georgetown in 1526, but it failed after 9 months. In 1663, King Charles II of England granted the territory that now comprises both North and South Carolina to eight lords proprietors,

The pentagonal design of Fort Sumter is clearly defined in an aerial photograph taken above Charleston Harbor. The fort was shelled by Confederate artillery in April 1861 in the earliest fighting of the Civil War.

one of whom was Anthony Ashley Cooper, later 1st earl of Shaftesbury. The first permanent settlement, at Charles Town (Charleston) on the Ashley River, was established by the English in 1670. (It was moved in 1680 to the peninsula between the Cooper and Ashley rivers.) Settlement spread from Charles Town south toward BEAUFORT (founded 1710), north toward Georgetown (1735), and inland along the rivers.

By the 1750s, Germans and Scottish-Irish from Pennsylvania and Virginia were settling the Piedmont on small, subsistence farms in contrast to the coastal plantations.

South Carolina was early in showing an independent spirit. In 1693 the colony won the right to initiate legislation in the colonial commons house. In 1719 the populace rebelled against the British proprietors and their reactionary policies, expelling them and electing James Moore as governor. As a result the British crown assumed (1729) jurisdiction, and North and South Carolina were constituted as separate colonies.

The Revolutionary War, after the British repulse at Charleston in 1776, temporarily bypassed South Carolina. Then the British captured Charleston on May 12, 1780. The numerous battles and skirmishes fought in the state after 1780 included important American victories at Kings Mountain and Cowpens (see COWPENS, BATTLE OF).

South Carolina was the eighth state to ratify the federal Constitution, on May 23, 1788. To mollify Piedmont settlers, who demanded increased representation, the General Assembly agreed in 1786 to move the capital. Columbia was established as the new seat of government. In the first federal census of 1790, South Carolina's population of 249,073 ranked 7th. Nonwhites accounted for 43.7% of the total and were concentrated in the low country around Charleston.

Of major economic importance was the adoption at the end of the 18th century of short-staple, green-seed cotton. Its success turned many Piedmont farmers into slave-holding planters and unified the state economically, socially, and politically.

During the 1820s and '30s cotton prices collapsed, and the state's economy and population growth stagnated. Blaming these problems on the national tariff policies, South Carolina—led by Vice-President John C. CALHOUN—asserted its right to nullify federal legislation. In 1832 a special state convention nullified the Tariff Act of that year. President Andrew Jackson responded to this action with a Force Act. The NULLIFICATION crisis was resolved by compromise, but STATE RIGHTS sentiment continued to grow in South Carolina.

Dissatisfaction culminated in the convention that, on Dec. 20, 1860, voted to remove South Carolina from the Union, the first Southern state to secede. The Civil War began on Apr. 12, 1861, with the firing on Fort Sumter in Charleston Harbor. Beaufort and Port Royal fell to Union forces on Nov. 7, 1861, but not until Sherman's invasion of the state at the beginning of 1865 was the impact of war felt. Severity of property loss, however, paled before the mortality figures for South Carolina: about 25% of the 63,000 who served were killed.

Reconstruction was hard on South Carolina, and corrupt officials left the state with heavy debts. Poor cotton prices and severe soil erosion after 1880 stymied economic improvement, and agricultural distress led to political success for the farmers' movement. A state constitutional convention in 1895 largely disenfranchised blacks. Strong populist leanings characterized politics for decades.

By 1910 rice production had virtually disappeared, although cotton remained the state's leading crop into the 1950s. During the late 19th century the tenant system developed, and in 1930 it characterized 65% of the state's farms. During the early 20th century urban concentrations developed around Piedmont textile centers such as Greenville and Spartanburg, and the out-migration of blacks reduced their percentage of the population.

World War I temporarily revived agricultural fortunes, but an economic depression, which lasted for two decades, and infestation by the boll weevil, which destroyed

The Blue Ridge Mountains, which form a segment of the Appalachian Mountains of eastern North America, occupy the northwestern corner of South Carolina.

half the cotton crop, began in 1921. World War II was a watershed in South Carolina's history, enormously increasing emphasis on industrialization. By the early 1950s the state was actively seeking industry to complement the textile mills that had virtually monopolized the nonagricultural sector of its economy. This, complemented by a diversifying agricultural base, underpinned an expanding economy.

Despite the 1954 Supreme Court decision (see Brown v. Board of Education of Topeka, Kansas), South Carolina initially resisted racial integration, but in the 1960s school integration was achieved. Hurricane Hugo in 1989 did much damage in a dozen of the state's counties.

South China Sea see China Sea, South

South Dakota South Dakota is located in the center of the North American continent, bounded on the north by North Dakota, on the east by Minnesota and Iowa, on the south by Nebraska, and on the west by Wyoming and Montana. Its area of 199,743 km^2 (77,121 mi^2) ranks 17th among U.S. states. The population is 699,999 (1990), ranking 45th. The capital is Pierre (pronounced *peer*).

Dakota is a Sioux word meaning "alliance of friends." The state's nicknames include "Sunshine State" and "Coyote State." The territory was explored by the French in the mid-18th century, and settlement began in 1857. On Nov. 2, 1889, South Dakota became the 40th state in the Union. South Dakota has traditionally been an agricultural state, but recently it has become a major tourist center and has also experienced commercial and industrial growth.

Land and Resources

The state is divided in half by the north-south–flowing Missouri River. The state's elevation averages 670 m (2,200 ft).

Glaciated eastern South Dakota is known as Prairie Country. The melted ice left the land covered with glacial debris, resulting in low rolling hills, marshy areas and small lakes, and shallow river valleys. The eastern part of the state is covered with rich chernozem prairie soils.

Unglaciated western South Dakota is part of the Great Plains. It is composed of smooth hills, isolated buttes, and flat dissected plateaus. Fertile chestnut brown soils cover the drier plains. The beautiful, castellated Badlands follow the White River in the southern part of the state.

The Black Hills form a third topographic region in the

AT A GLANCE

SOUTH DAKOTA

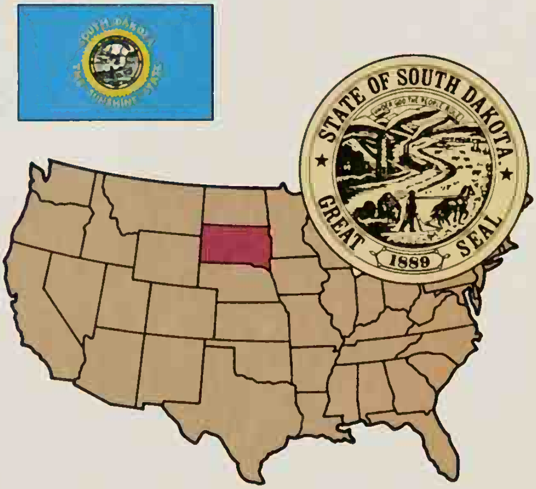
Land: Area:199,743 km^2 (77,121 mi^2); rank: 17th. Capital: Pierre (1990 pop., 12,906). Largest city: Sioux Falls (1990 pop., 100,814). Counties: 66. Elevations: highest—2,207 m (7,242 ft), at Harney Peak; lowest—294 m (966 ft), at Big Stone Lake.

People: Population (1990): 699,999; rank: 45th; density: 3.5 persons per km^2 (9.2 per mi^2). Distribution (1990): 50% urban, 50% rural. Average annual change (1980–90): +0.13%.

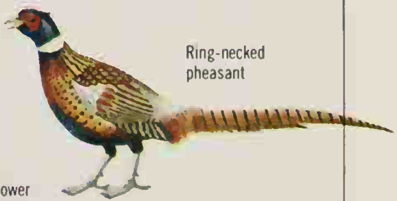
Government (1993): Governor: George S. Mickelson, Republican. U.S. Congress: Senate—1 Democrat, 1 Republican; House—1 Democrat. Electoral college votes: 3. State legislature: 35 senators, 70 representatives.

Economy: State personal income (1989): $9.8 billion; rank: 47th. Median family income (1989): $27,602; rank: 45th. Agriculture: income (1989)—$3 billion. Lumber production (1991): 168 million board feet. Mining (nonfuel): value (1988)—$286 million. Manufacturing: value added (1987)—$1.5 billion. Services: value (1987)—$1.9 billion.

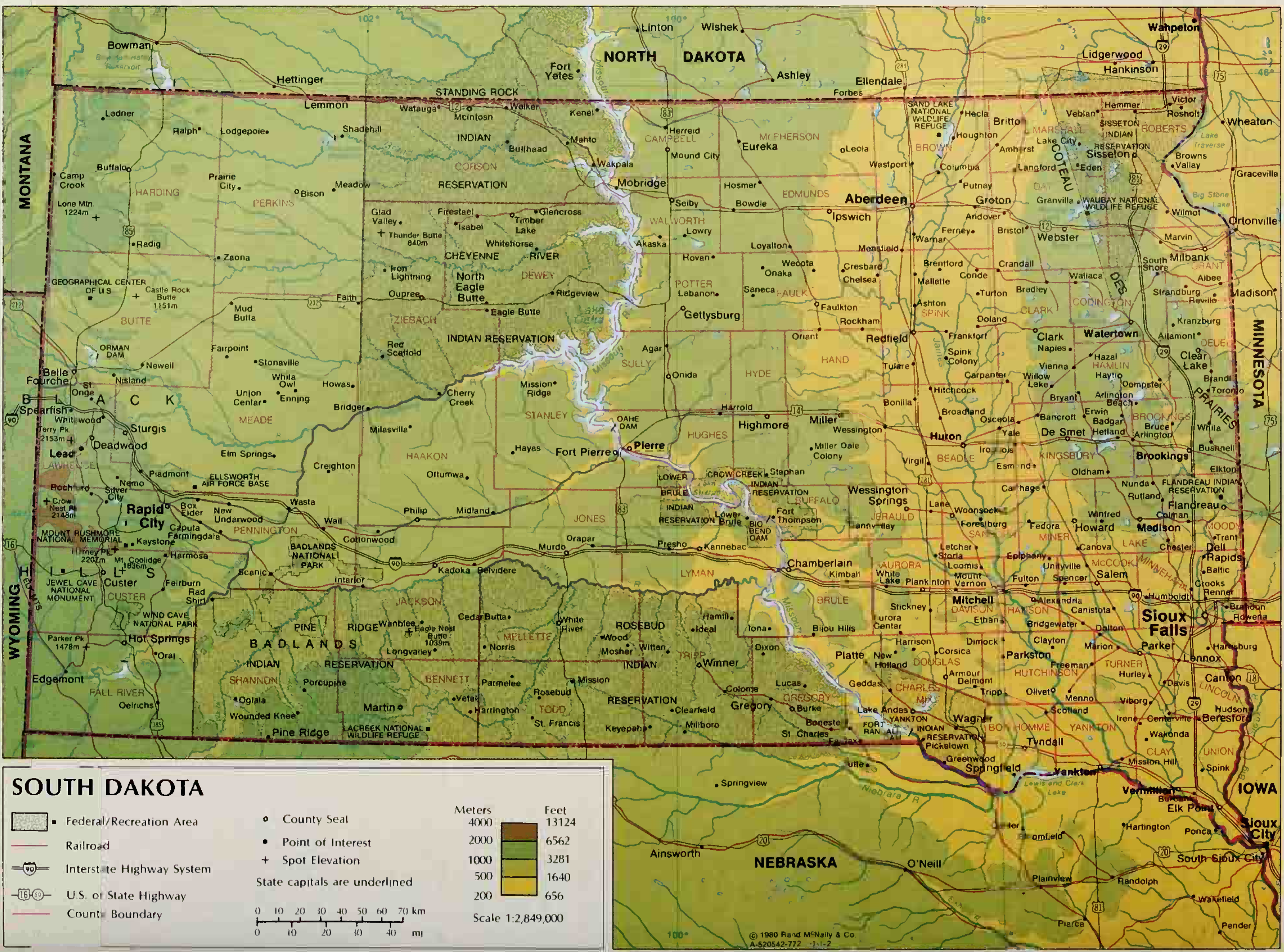
Miscellany: Statehood: Nov. 2, 1889; the 40th state. Nicknames: Sunshine State, Coyote State; tree: Black Hills spruce; motto: Under God the People Rule; song: "Hail, South Dakota."

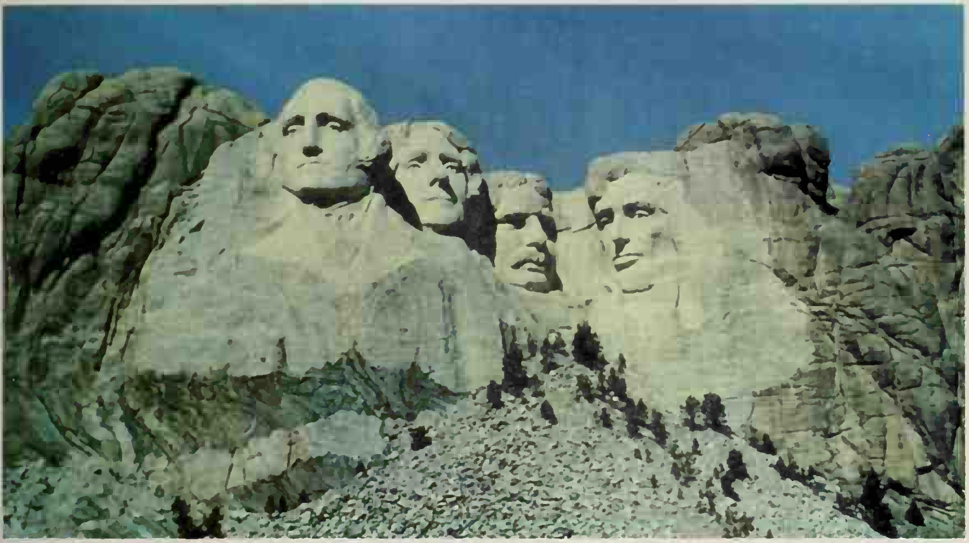


Pasqueflower


Ring-necked pheasant

SOUTH DAKOTA





The features of four U.S. presidents—Washington, Jefferson, Theodore Roosevelt, and Lincoln—were carved into the granite face of Mount Rushmore by Gutzon Borglum over a period of 14 years. The sculpture, in southwestern South Dakota, is a national monument.

southwest corner. They are a domed mountain region composed of an ancient crystalline core with deep valleys, surrounded by ridges of sedimentary strata. The state's highest point, Harney Peak (2,207 m/7,242 ft), is located in the Black Hills. Thin, infertile gray wooded soils are found there.

Climate and Drainage. The climate is continental with distinct seasons. In January temperatures average from −12° to −7° C (10° to 20° F) in the north and between −7° and −4° C (20° and 24° F) in the south. In July temperatures range from 18° to 21° C (65° to 70° F) in the north, and between 21° and 24° C (70° and 75° F) in the south. Precipitation varies from 660 mm (26 in) in the southeast to 330 mm (13 in) in the northwest. The state can experience blizzards during winter and severe thunderstorms and tornadoes in spring and summer.

The MISSOURI RIVER, which flows into the Mississippi River and then to the Gulf of Mexico, receives drainage from all regions but northeastern South Dakota, which drains into the Hudson Bay. Principal eastern streams are the Big Sioux, Vermillion, and James rivers. The major western streams are the Grand, Moreau, Cheyenne, Bad, White, and Keya Paha rivers. The two largest natural lakes are Big Stone and Traverse, both in the northeast; the many large artificial lakes include Lake Oahe.

Vegetation, Animal Life, and Resources. Vegetation ranges from tall prairie grasses in the east to short steppe grasses in the west. Coniferous forests cover the Black Hills, and some deciduous trees such as elm, oak, box elder, and cottonwood occur along streams and in eastern shelterbelts. Animal life varies from pheasant, jackrabbit, and coyotes to antelope and bison.

South Dakota's resources include fertile farmlands, rich grazing areas, and forests. Minerals include gold, stone, silver, mica, beryl, uranium, lignite, and petroleum. Reservoirs on the Missouri River impound surface water.

People

South Dakota is sparsely populated, ranking 45th among U.S. states in number of residents. In recent years the state has experienced significant out-migration due to a lack of jobs. The population is less than half urban. RAPID CITY and SIOUX FALLS are the two principal cities. Aberdeen and PIERRE are also important.

The population is predominantly white, with only 7.3% Indian and 0.5% black. Many settlers came from New England and New York, and the major European immigrants were German, Norwegian, Swedish, and Danish. The major religious groups are Lutheran, Roman Catholic, and Methodist.

A solitary truck travels past the eroded landscape of the Badlands in southwestern South Dakota. Much of the Badlands lies within large Indian reservations, but a portion of this arid region is maintained as a national park.

Education, Culture, and Communications. Public school districts were established by law in 1862 but were reorganized in 1968 to place a greater emphasis on regional schools. The several state institutions of higher education include The University of South Dakota (1862) at Vermillion. Augustana College (1860) in Sioux Falls and National College (1941) in Rapid City are the largest private colleges in the state.

Excellent museums include art museums at Brookings and Vermillion; Indian and geological museums at Rapid City; the Adams Museum at Deadwood, with historical exhibits; and the Pettigrew Museum in Sioux Falls, with Indian, historical, and natural history exhibits. South Dakota has several daily newspapers. It is served by commercial radio and television stations.

Tourism and Recreation. Historic sites include DEADWOOD, an old mining town that included Calamity Jane and Wild Bill Hickok among its residents; Yankton, the first capital of the Dakota Territory; Fort Pierre, site of the earliest trading post; and the WOUNDED KNEE Battlefield, located near Pine Ridge in the Oglala Sioux Indian reservation. Mount RUSHMORE is a national memorial in the Black Hills. National parks include Badlands and Wind Cave (limestone caverns located in the Black Hills). Recreational activities—hunting, fishing, camping, boating, skiing, and skating—take place in South Dakota's national parks and major state recreation areas.

Economic Activity

South Dakota is still a predominantly agricultural state, but both tourism and manufacturing have increased in importance since World War II, and mining is a vital part of the state economy.

Manufacturing and Energy. Manufacturing is growing rapidly, with meat packing the largest single industry in the state. Other major industries are food products; nonelectrical machinery, including farm and construction equipment; printing and publishing; lumber; electrical equipment; and stone, clay, and glass products.

The four federal dams on the Missouri River—Big Bend, Fort Randall, Gavins Point, and Oahe—along with smaller hydroelectric plants and coal-burning plants furnish residents with excellent access to electrical power. The state has limited petroleum and lignite reserves. Natural gas supplies are limited to extreme eastern and western cities.

Agriculture and Forestry. Agriculture is the most important segment of the economy. Livestock production accounts for the majority of the state's agricultural income. The leading livestock commodities include beef cattle, hogs, lambs, and sheep. Principal crops grown in the state are wheat, hay, and corn. South Dakota is the leading U.S. producer of rye, flax, durum wheat, alfalfa seed, and sunflowers. The state's forest-product firms in the Black Hills utilize the ponderosa pine as a principal source of timber.

Mining and Transportation. The Homestake Mine in Lead is the nation's largest gold mine. Other major minerals are sand, gravel, and stone. Uranium was discovered in 1951 and petroleum in 1953.

A herd of Hereford cattle are watered at a small pond. South Dakota's farm economy is dominated by livestock and related products. Millions of head of cattle are raised on its ranches, found mostly in the eastern portion of the state.

The major interstate highway in South Dakota is I-90, which crosses the state in an east-west direction, passing near Sioux Falls in the east and Rapid City in the west. Rail service has declined, and no passenger service is available. Commercial airlines serve several cities and towns.

Government and Politics

The state constitution was adopted in 1889. It provides for a 35-member senate and a 70-member house of representatives, with members of both houses serving 2-year terms. The executive branch is composed of a governor, lieutenant governor, and 5 administrative officials elected to 4-year terms. The judiciary is composed of a supreme court with 5 judges who serve 8-year terms, and circuit court judges who also serve for 8 years. South Dakota has usually been a staunchly Republican state.

History

About AD 500 the MOUND BUILDERS appeared along the Big Sioux River. By the 1500s, the Arikara inhabited the area.

The territory was explored (1742–43) by the brothers François and Louis Joseph La Vérendrye, who claimed the land for France. In 1762, France ceded the area (which was part of the huge territory called Louisiana) to Spain, and thereafter both the SIOUX Indians and European fur traders began filtering into the territory. The Sioux pushed the Arikara westward. Spain returned the area to France in 1800.

In 1803 the United States acquired the area as part of the Louisiana Purchase. Trading posts such as Fort Pierre (established 1817) prospered with the fur trade. The first permanent European settlement was at Yankton in 1859. In 1862, Yankton became the capital of the newly established Dakota Territory. The number of settlements increased rapidly with the coming of the railroad in the 1870s.

In 1874, Gen. George CUSTER led an exploratory expedition into the Black Hills, discovering gold. With the resultant influx of settlers, new towns such as Deadwood were established. With new settlers, conflicts with the Sioux intensified, as much of the land had previously been granted to the Sioux by treaty. Although General Custer and his troops were defeated (1876) at the Battle of the LITTLE BIGHORN, Indian resistance was finally crushed with the massacre at Wounded Knee (1890). Since then the Indian population has primarily resided on the eight reservations in South Dakota. In 1973, as a means of drawing attention to Sioux grievances, some 200 armed Indians occupied Wounded Knee for 70 days.

With the opening of land to homesteading, the population increased to 281,000 by 1890. North and South Dakota finally became states simultaneously on Nov. 2, 1889.

Under the governorship (1917–21) of Peter Norbeck the state government became involved in various commercial enterprises such as railroad rates regulation, coal mining, insurance, and credit. With the exception of the state cement plant, these failed dismally and left South Dakota deeply in debt by the mid-1920s. These failures combined with the Depression and the Dust Bowl droughts of 1933 and 1934 to put the state into a financial crisis that was not resolved until 1946.

Since World War II the state has progressed, building a strong agricultural base on which to develop tourism, industry, and commerce. Despite these developments, the state's Indian reservation residents have not kept pace and have continued to suffer an unemployment rate of more than 80%. That and the troublesome issue of tribal jurisdiction created incidents of racial conflict and other problems for the state in the 1980s.

South India, Church of The Church of South India is the result of the union of churches of varying traditions—Anglican, Methodist, Congregational, Presbyterian, and Reformed—in that area. It was inaugurated in September 1947, after protracted negotiation among the churches concerned.

Organized into 16 dioceses, each under the spiritual supervision of a bishop, the church as a whole is governed by a synod, which elects a moderator (presiding bishop) every two years. The Church of South India represents the first successful attempt since the Reformation to unite episcopal and nonepiscopal communions and for this reason is regarded as an ecumenical landmark.

South Moluccans see AMBONESE

South Pole The South Pole is that location marking the southern end of the Earth's axis of rotation. The pole is located on the continent of Antarctica, at 90° south latitude, and, along with the North Pole, is one of two locations on Earth that receive 6 months of continuous daylight and 6 months of continuous darkness each year. The South Pole has an altitude of 2,800 m (9,186 ft). It was first reached by Roald AMUNDSEN in 1911.

South Sea Bubble The South Sea Bubble is the name given to a speculative boom in England that collapsed in 1720. The financial disaster was caused by the South Sea Company, founded for trade in 1711. Stock in the company sold well, and by 1718 investors were receiving 100 percent interest. In 1720 the company proposed—and Parliament accepted—that it take over much of the national debt. This move created a wave of speculation in the company's stock, which rose from £128½ in January to £1,000 in August. In September the bubble burst. Stocks plummeted, banks failed, and investors were ruined. Robert WALPOLE, however, was able to restore the company's credit and save the Whig government.

South Sea Islands see OCEANIA

South West Africa see NAMIBIA

Southampton [sowth-amp'-tuhn] Southampton is a port city of 207,500 (1982 est.) in southern Hampshire, England, where the rivers Test and Itchen combine to form the estuary of Southampton Water. The Isle of Wight shelters the approaches to the harbor. Southampton's principal industry is the building and repairing of ships. Extensive docks, some built as early as 1831, include a dry dock capable of accommodating the largest ocean liners. The University of Southampton (1952) is there.

Romans and Saxons settled on the site, and after the Norman Conquest (1066), Southampton served as England's chief military base and port. In the 18th century Southampton was a fashionable resort, becoming an important port once again after the arrival of the railroad from London (1840) and the construction of modern docks. It was heavily bombed during World War II.

Southampton Island Southampton Island, at the entrance to Hudson Bay, in Canada's Northwest Territories, has an area of about 40,660 km^2 (15,700 mi^2). Sighted in 1613 by Thomas Button, it was used as a whaler's base from 1860 to 1920.

Southeast Asia *Southeast Asia*, a term used since World War II, usually refers to the region south of China and east of India and includes Thailand, Laos, Vietnam, Cambodia, Burma (Myanmar), Indonesia, Malaysia, Brunei, the Philippines, and Singapore. Europeans began to penetrate the area during the 16th century and gradually colonized it. The strategically important region was the focus of heavy fighting during World War II. Except for Thailand, which was never colonized, the Southeast Asian nations did not gain independence until after World War II. Many of them have made great economic progress, despite the prolonged Vietnam War and other postwar conflicts.

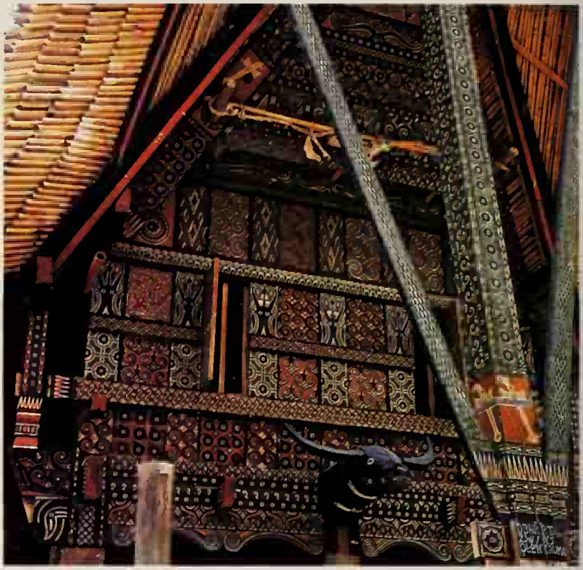
Southeast Asia Treaty Organization A treaty signed in Manila in 1954 by Australia, France, Great Britain, New Zealand, Pakistan, the Philippines, Thailand, and the United States created the Southeast Asia Treaty Organization (SEATO), a defensive alliance. Its protective umbrella was meant to shelter the Asian signatories in addition to Cambodia, Laos, and South Vietnam under a special protocol. The signatories pledged collective action in case of external aggression or internal subversion against any one of them, as well as economic cooperation, but the priority was always on anticommunist and military measures.

SEATO members were reluctant to support U.S. involvement in the Vietnam War. In 1972, following the Indo-Pakistani War, Pakistan withdrew from SEATO; in 1977, the organization was dissolved.

Southeast Asian art and architecture Southeast Asian art and architecture comprise the artistic traditions of the southeastern Asian mainland and a vast arc of islands extending from Sumatra in the west to Sulawesi (Celebes) in the east. The present-day countries in this area include Burma (Myanmar), Thailand, Laos, Vietnam, Cambodia, Malaysia, and Indonesia. The Philippines, although in many ways similar to the other countries of Southeast Asia, never shared in the main cultural influence that united the rest—the spread of Indian culture, which took place gradually from about AD 20 to about 1200. In the wake of Indian merchants and settlers came the two major Indian religions, Hinduism and Buddhism, which provided the inspiration for most Southeast Asian monumental art. Lastly, the travels of Buddhist monks and pilgrims were a significant factor in the cultural evolution of this vast and disparate region.

Indigenous Folk Traditions. Prior to the impact of Indian culture, Southeast Asia seems to have been a part of the great web of animist culture and religion that still extends out through New Guinea and the Melanesian, Micronesian, and Polynesian islands of the Pacific (see OCEANIA, ART OF). With the aid of stone tools, tribal artisans used wood, especially the omnipresent bamboo, to build houses and shrines and to carve artistic objects such as funereal effigies. The houses seem to have followed a fairly consistent pattern throughout the region. Common elements include floors raised on piles; strong center and corner posts; woven or plank walls; and vast, towering gable roofs masking complex inner structures and usually covered with palm fronds or thatch. Some of the most important structures are painted in brilliant colors.

The stylized designs of these structures refer to spirit beings and to ceremonials, especially buffalo sacrifice. According to animist beliefs, the spirits of the dead are to be pacified and worshiped if they are ancestors, enslaved if they are enemies; therefore, the cult worship of the skull as a receptacle of a dead person's spirit traditionally has pervaded the whole area. Many tribes made (and still make) *korvars* (wooden figures in which the skulls of ancestors are incorporated); most villages have skull shrines; and the original designs of the predyed and woven ceremonial textiles called ikat appear to represent early references to the dead, to skulls, and to spirit beings. Among the many objects still looked on with religious awe as repositories of spiritual power are large and small stones, bronze drums, and finely ornamented swords called kris or keris.



A Toradja house in Sulawesi (Celebes), Indonesia, is painted with abstract motifs typical of indigenous folk art. Architectural designs such as these are associated with the traditional animistic beliefs of the Indonesian peoples.

Prehistoric stone tools were made of a variety of stones, including semiprecious jasper, agate, and chalcedony. The more sophisticated tools were produced in two principal forms: the adze, or ax, of rectangular section, which seems to have been distributed southeastward from Malaysia into the Indonesian islands; and the pickadze, triangular or five sided in section, with a top rib. Ancient examples of these implements are still treasured as powerful communal AMULETS.

Ancient Megalithic and Dong-son Cultures. By about 1000 BC, the people known as the MON of Thailand and southern Burma apparently were making large stone funerary monuments that were ornamented with figures. These monuments may have been connected with a megalithic culture extending westward beyond India and southern Arabia through Malaysia and Indonesia. Sizable stone coffins finely carved in the round have been found at Lake Toba on Sumatra, and ornamented menhirs (freestanding stones) appear on various islands.

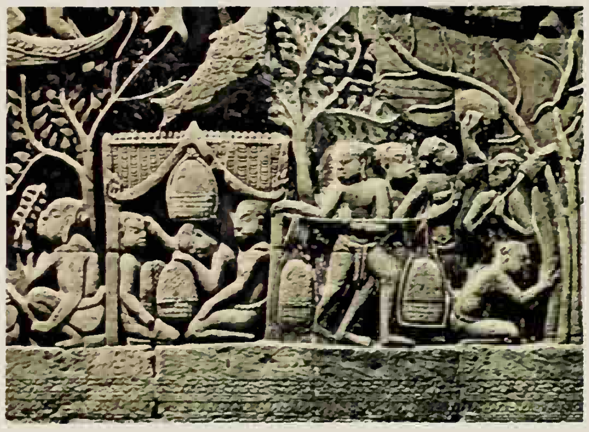
About 700 BC an important bronze-using culture appeared on the Tonkin plain, in present-day northern Vietnam. Called Dong-son, after one of its principal sites, this culture seems to have spread by sea along the mainland coast and down into the main islands of Indonesia. Along with the first really extensive use of bronze, the Dong-son disseminated throughout the region a decorative style related to that of the late Zhou period (770–221 BC) in China. The chief characteristic of the Dong-son style is the frequent use of heavy, slightly square spirals in relief; other motifs include key patterns and rows of dots. Although Dong-son artists decorated lamps, weapons, bowls, huge ceremonial jars shaped like axes, and in-the-round human and animal figures, their most important works were large bronze drums, or drum-shaped gongs, that perhaps were used in rain ceremonials. Of the many such drums dating from the period 500–100 BC, the largest, known as the Moon of Bali, stands 1.8 m (6 ft) high and is still revered in the temple at Pedjeng, Bali. After the Dong-son homeland was occupied (111 BC) by the Han Chinese, Dong-son culture was eclipsed by Chinese and, later, Indian influence.

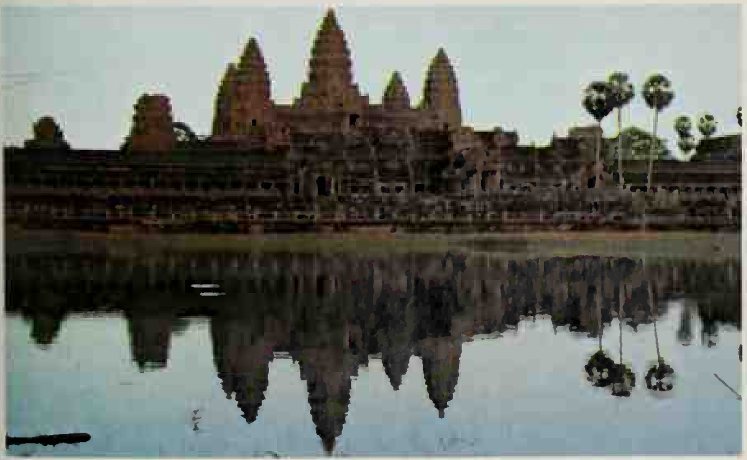
Cambodia and Vietnam

Artistically as well as politically, the most important of the Indianized cultures of ancient Southeast Asia was that of Cambodia. Cambodia probably was first colonized from India in the 1st century AD, when a kingdom known to the Chinese as Funan was established on the lower Mekong River. The Funan state was succeeded in the 5th century by another kingdom, known as Chen-la, centered upriver in what is now Laos. Among artworks that have already been recovered is a remarkable series of powerfully sculpted stone images of Buddhist and Hindu deities, along with a few remaining wooden Buddha figures. Although these early Cambodian works echo Indian sensuousness and concern for anatomical detail, they also display an architectonic and monumentalized quality foreign to Indian art.

The full flowering of Cambodian culture took place under the KHMER EMPIRE, which ruled much of what is present-day Cambodia and Laos from the 7th to the 15th century. Firmly based in Indian culture and artistic motifs, Khmer art is characterized by grandiose and monumental forms, particularly in architecture and architectural decoration. A growing emphasis on the exalted status of god-kings led successive Khmer monarchs to build increasingly elaborate religious edifices, from the isolated brick towers of the 7th century to the vast complex built (9th–13th century) at ANGKOR. At Angkor, the largest integrated complex of architecture and sculpture ever built, a net of huge reservoirs and canals encloses the great temple mountains of successive kings. Assemblages of shrines are linked by cloisters, corridors, and stairways. Culminating in the colossal (1,500-by-1,300-m/4,920-by-4,265-ft) Angkor Wat built by Suryavarman II (r. 1113–50), all the temple mountains of Angkor were filled with three-dimensional images and miles of relief sculpture that covered every inch of available wall space. After Angkor Wat was sacked (1177) by the Cham, Jayavarman VII (r. 1181–*c.*1218) constructed the biggest shrine of all, called the Bayon, inside his own city, Angkor Thom. The 15th-century conquest of the Khmer kingdom by the Thais resulted (1431) in the final abandonment of Angkor.

The Cham people, whose history reflects a long (1st–15th century) struggle for existence pressed between the Chinese and the Khmer, built a series of small but elaborately ornamented Hindu tower shrines, first (4th–11th century) at Mi Son in the north, then (11th–15th century)





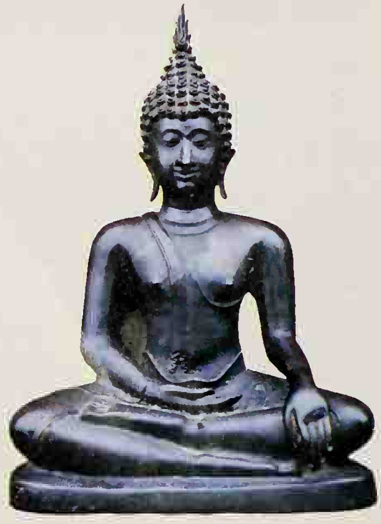
(Above) *The delicate bas-reliefs that ornament the gallery walls of Angkor Wat depict mythological and legendary scenes, especially the events associated with Vishnu, the Hindu deity to whom the shrine is dedicated. This elegant relief sculpture was originally painted and gilded. The city of Angkor was the capital of the Khmer empire from* AD *880 until the 13th century.* (Left) *Angkor Wat, the greatest temple of the sacred city of Angkor, Cambodia, remains one of the most impressive examples of temple architecture. Constructed during the early 12th century, the elaborate architectural design of Angkor Wat is derived from the stupa form and represents the golden age of Khmer art. The compound at Angkor Wat covers an area of 1,500 by 1,300 m (4,920 by 4,265 ft).*

at Binh Dinh in the south. A characteristic feature of Cham temple architecture is the multilobed arches above porticoes, decorated with carved foliage springing from the mouth of a monster. Cham sculpture is notable for its powerfully modeled forms. Most other art of ancient Vietnam, known to us only in fragments, can be described as provincial versions of Chinese models.

Thailand

The first great dynastic state of present-day Thailand was the Dvaravati kingdom established (6th century) by the Eastern Mon people. Between the 6th and 11th century, the largely Buddhist Mon produced a significant body of STUPA (Buddhist temple mounds) architecture. The most important examples of Mon–Dvaravati art to survive are Buddhist sculptures of the 6th–8th century, executed in bronze or stone, that display typically Mon faces, with delicate, turned-out lips and almond-shaped eyes. In the 11th century, southern Dvaravati became part of the Khmer Empire, and Khmer styles of architecture and sculpture were imposed.

The eclipse of the Dvaravati kingdom was followed by infiltration into northern Thailand of the ethnic Thai, an animist people whose northern capital was at Chiengmai. After the Khmer downfall in the 13th century, another Thai branch established a kingdom (fl. 1350–1767) in the southern and central areas of the country, with its capital at AYUTTHIA (Ayuthaya). Control over the great Buddhist city of Sukhothai was continually disputed between the northern and southern Thais. The principal Thai architectural form was a tall, tapering, bell-shaped, ornamented stupa set amid associated monastic structures. Large-scale sculpture, the principal art of Sukhothai and Ayutthia, was devoted to sacred, highly spiritualized bronze Buddha icons. During the 14th century, Sukhothai produced a basic set of Buddha types whose smooth and sinuously curved surfaces, looped linear features, and tightly curled hair crowned by a flame or lotus-bud headdress are well represented in the so-called *Walking Buddha* (14th century; Monastery of the Fifth King, Bangkok). Two other sculptural styles, the northern Chieng Sen type (15th–16th century) and the southern U Tong type (14th–16th century), evolved later. Close versions of these three types are still made today. Paintings in styles related to Thai sculpture adorned the interiors of shrines and halls. Fine ceramics, versions of Chinese originals, were made in Thailand from the 14th century on, notably at Sawankhalok, Sukhothai, and Chiengmai.



This 14th-century bronze Buddha with his right hand resting in the traditional position of calling earth to witness (bhumisparsa) *belongs to the high Classic period of Sukhodaya art. Artisans at Sukhothai, a Buddhist city of central Thailand, worked prolifically in bronze, abandoning the elaborate designs of Khmer art to produce pieces noted for their simplicity and fluidity.*

Burma

Burmese art also was predominantly Buddhist. In the north flourished the kingdom of the Pyu people, which was known to the Chinese for its large and wealthy cities. Still extant at Hmawza, the Pyu capital, are three huge brick stupas whose cylindrical structures and bell-shaped domes set the pattern for all later Burmese stupas. Southern Burma was ruled by the Western Mon, who were confederated with, and shared the art styles of, the Dvaravati culture. During the 10th century the north was infiltrated by the ethnic Burmese, an animist people who introduced a set of spirit beings called the 36 *nats*. When they were converted to Theravada Buddhism, the Burmese included the Buddha as the 37th *nat*.

In the 11th century, the Burmese king Anawratha united the entire country and carried off Mon monks and artisans to his northern capital, PAGAN, which was continually embellished and expanded until the Mongol conquest of 1287. Pagan still stands today, the largest surviving example of the great medieval complexes of brick and plaster that once were widespread in Southeast Asia.

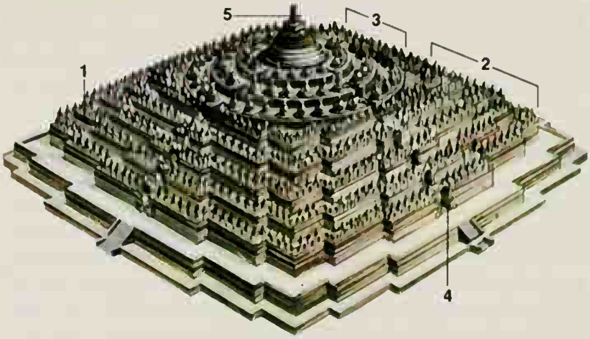
In southern Burma, notably at Rangoon and Mandalay, Buddhist followers built vast monastery complexes whose buildings have been continually torn down and refurbished with plaster cladding and gilt ornament, flaring porches, elaborately ornamented doors, and finials.

Indonesia

Indian traders and settlers first reached the Indonesian islands in the 1st century AD, bringing with them both Buddhism and Hinduism. From the 3d to the 6th century, Buddhist monasteries apparently were built in the Sumatran kingdom of Shrivijaya and in Sulawesi, where a fine early bronze Buddha has been found. The oldest Javanese monuments, all undated, are Hindu shrines erected on volcanic mountain plateaus; they were dedicated to the god Shiva. The huge Buddhist stupa mountain of BOROBUDUR, built about 800 in stone and profusely decorated throughout with ornate sculpture, is the largest structural MANDALA (cosmic diagram) in the world.

The largest Javanese religious complex is the Hindu shrine of Lara Jonggrang, built about 900 at Prambanan. Originally, 232 separate temples were incorporated into the Prambanan complex; the fact that its temple towers are adorned with rows of small Buddhist stupas illustrates how the two great Eastern religions intermingled in ancient Indonesia. Superb figure sculpture depicting Hindu epics runs around the balconies in a manner similar to

(Left) *The Shwesandaw* cetiya *(1047), a Burmese architectural innovation combining the attributes of stupa and shrine, stands in the ruins of Pagan, the capital of Burma until the late 13th century. Within this* cetiya, *which consists of 5 square, receding terraces resting on an octagonal base, are contained Buddhist relics.* (Below) *The structure of the Buddhist monument (800) at Borobudur, Java, designed with 8 diminishing terraces connected by stairways, symbolically re-creates the Buddha's path toward spiritual enlightenment. A pilgrim ascends along the corridors* (1) *of the square lower terraces* (2), *representing this world, and then rounds 3 terraces of the world of God* (3), *rising in concentric rings of 72 stupas. Passageways* (4) *rise at each cardinal point from the first terrace to the summit. The top of the shrine is surmounted by the Great Stupa* (5), *goal of the pilgrimage and symbol of Eternal Truth.*



the Buddhist work at Borobudur.

Beginning in the 11th century, relief sculpture developed toward the deeply incised and caricatured forms of what is now known as the Wayang puppet style, although splendid three-dimensional icons of Hindu and Buddhist deities were still executed. Particularly fine reliefs are the 14th-century terra-cotta panels that once adorned the walls of the capital city of Majapahit with elaborate landscape images as well as figures of deities and spirits.

In the 15th century, Islam largely supplanted Indian culture throughout Indonesia, except in Bali, where a modified form of East Javanese religion survives.

Southeast Asian languages Approximately 1,000 mutually unintelligible languages are spoken in Southeast Asia, of which only the major national and regional languages have writing systems and literary traditions. From the standpoint of genetic relationship, the languages can be divided into nine separate stocks: Sinitic (or CHINESE), Tibeto-Burman, Karen, Miao-Yao, Tai, MALAYO-POLYNESIAN (or Austronesian), Mon-Khmer, Viet-Muong, and Papuan.

The first five stocks have traditionally been classed as SINO-TIBETAN LANGUAGES. It has also been proposed that Miao-Yao, Tai, and Malayo-Polynesian are related in an Austro-Thai stock. Most authorities agree that Viet-Muong is related to Mon-Khmer in an Austroasiatic stock, but the further affiliation of Austroasiatic with Malayo-Polynesian in an Austric superstock is more speculative. Some scholars suggest that all nine stocks are related in an Indo-Pacific family, but none of these larger groupings has been conclusively demonstrated.

Sinitic languages—particularly Cantonese, Hokkien, Hakka, and Mandarin—are spoken by large Chinese communities in the major cities of Southeast Asia, such as Singapore, Bangkok, and Manila. Among the Tibeto-Burman languages are Burmese, the national language of Burma, and hundreds of related languages such as Chin and Kachin in Burma, Akha and Lisu in Thailand, and Lolo in Laos and Vietnam. Karen languages, spoken by small minorities on both sides of the Thai-Burmese border, are probably related to Tibeto-Burman. The Miao-Yao languages, also called Meo and Man, are found in northern Thailand, Laos, and Vietnam and are spoken by small numbers of relatively recent immigrants from southern China. The Tai family comprises Thai, or Siamese, and Lao—the national languages of Thailand and Laos—and such minority languages as Shan in the Shan states of Burma, and Black Tai, Nung, and Tho in northern Vietnam.

The Malayo-Polynesian family stretches a third of the way around the globe, from Madagascar to Taiwan, and includes such national languages as Malay in Malaysia, Bahasa Indonesia in Indonesia, and Tagalog in the Philippines, as well as hundreds of regional and minority languages in these three countries and in the South Pacific.

The major representative of the Mon-Khmer family is Khmer, spoken in Cambodia as well as in adjacent areas of Thailand and Vietnam. Other Mon-Khmer languages are found among approximately 100 minority groups, such as the Mon and Palaung in Burma, the Lawa and Kuy in Thailand, the So in Laos, the Bahnar, Stieng, and Bru in Vietnam, and the Semang and Senoi in Malaysia.

The Viet-Muong group includes Vietnamese plus several closely related Muong languages spoken in northern Vietnam. The Papuan languages are found among indigenous groups in eastern Indonesia, especially in Irian Jaya (see OCEANIA, LANGUAGES OF).

Typologically, the Southeast Asian languages fall into two groups. The Sinitic, Tibeto-Burman, Karen, Miao-Yao, Tai, and Viet-Muong tend to be monosyllabic and tonal, relying heavily on word order for their meaning. The Malayo-Polynesian, Mon-Khmer, and Papuan languages, on the other hand, are typically disyllabic and nontonal and make use of a certain number of grammatical affixes. Southeast Asian languages as a whole are characterized by complex systems of status-related personal pronouns, a high degree of semantic specialization in the verb, and the use of classifiers, or counters, in numerical noun phrases.

Southern, Terry An American novelist, humorist, and screenwriter, Terry Southern, b. Alvarado, Tex., May 1, 1924, mingles black humor, parody, and satire in outrageous proportions. His fiction includes *The Magic Christian* (1960; film, 1971); *Candy* (1964; film, 1968), his parody of an erotic novel; and *Red-Dirt Marijuana and Other Tastes* (1967), short stories. Southern also collaborated on the screenplays for *Dr. Strangelove* (1963), *The Loved One* (1964), and *Easy Rider* (1969).

Southern Christian Leadership Conference A U.S. CIVIL RIGHTS organization founded (1957) in Atlanta, Ga., under the leadership of Dr. Martin Luther KING, Jr., the Southern Christian Leadership Conference (SCLC) reflected Dr. King's philosophy of assertive nonviolence and was intended to broaden the civil rights effort through peaceful but potent demonstrations. In 1963 the SCLC campaigned for desegregation of restaurants, hotels, and department stores in Birmingham, Ala., and organized the March on Washington, where about 250,000 Americans gathered in support of civil rights legislation. The organization also conducted voter-registration drives in the South, including one in 1965 that focused national attention on SELMA, Ala. In the mid-1960s the SCLC's policy of nonviolence was challenged by more militant civil rights groups, and after Dr. King's death in 1968 the organization lost its dominant position among African Americans.

Southern Cross see CRUX

Southern Rhodesia see ZIMBABWE

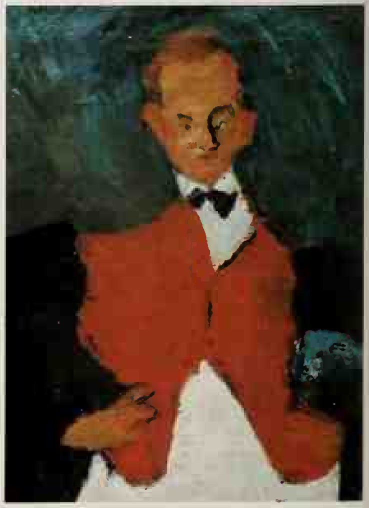
southern white cedar The southern white cedar, *Chamaecyparis thyoides*, is a swamp or bog tree in the cypress or cedar family, Cupressaceae. Native to freshwater swamps and bogs in eastern North America, it reaches 24 to 26 m (80 to 85 ft) in height. The crown is small and narrowly cone-shaped, composed of slender limbs and compressed, irregularly arranged branchlets. The wood is light, soft, and fragrant and is used for boats, shingles, posts, and cabinetwork.

Southey, Robert [suhth'-ee] Although poet laureate of England, Robert Southey, b. Bristol, Aug. 12, 1774, d. Mar. 21, 1843, is best remembered as an associate of Samuel Taylor COLERIDGE and William WORDSWORTH. Southey's epics, *Joan of Arc* (1796), *Thalaba* (1801), *Madoc* (1805), and *The Curse of Kehama* (1810), achieved some contemporary success but are now read only for their historical significance. His *Life of Nelson* (1813), *History of Brazil* (1810–19), and *History of the Peninsular War* (1823–32) established him as one of the outstanding prose stylists of his time. *The Doctor* (1834–47), a work of fiction, contains his rendition of the children's tale "The Three Bears."

After leaving Oxford without a degree in 1794, Southey joined Coleridge in planning "Pantisocracy," a utopian colony of farmer-philosophers on the Susquehanna River in Pennsylvania, but the project fell through. He moved to Keswick in 1803 to be near Coleridge and there met Wordsworth. The three poets were grouped and criticized by reviewers as the "Lake school" of poets, although this grouping was justified by little besides their Cumberland location. Southey was made poet laureate in 1813.

Southwell, Saint Robert [sowth'-wel] Robert Southwell, b. *c.*1561, d. Mar. 4, 1595, was an English Jesuit poet and martyr of the Elizabethan period. After studies in France and Rome he was ordained (1584) a priest and returned (1586) to London to serve as missionary to the oppressed Roman Catholics. Captured in 1592, he was arrested, tortured, and finally executed. Southwell's religious poetry prefigures that of George Herbert and Richard Crashaw. Southwell was canonized in 1970 as one of the Forty Martyrs of England and Wales. Feast day: Oct. 25.

Soutine, Chaim [soo-teen', ky'-im] A Russian-born painter of the school of Paris, Chaim Soutine, b. 1893, d. Aug. 9, 1943, produced works characterized by a violent expressionism. He became a friend of the painter Amedeo Modigliani, who—through his dealer Leopold Zborow-



In The Head Valet *(1928), Chaim Soutine used flat shapes and violent brushwork to suggest the psychological content of the painting—a brutal portrait of a servant in a changing modern world. Soutine's expressionistic portrayals of anxious subjects constitute an important contribution to the school of Paris painting. (Walter Guillaume Collection, Paris.)*

ski—helped him to achieve artistic notice and the financial security that came with the patronage of the American collector Dr. Albert C. Barnes. In Soutine's work, unhappy memories seem to surface in the disturbed faces of the people he painted, the tumbled landscapes, and the famous still lifes with dead fowl or carcasses of beef. He generally smeared his canvases with a thick impasto of blood reds and gloomy grays and used savagely distorted proportions, as in *The Old Mill* (*c.*1922; Museum of Modern Art, New York City).

Souvanna Phouma [soo-vah'-nah foo'-mah] The Laotian neutralist politician Prince Souvanna Phouma, b. Oct. 7, 1901, d. Jan. 10, 1984, was prime minister (1951–54, 1956–58, 1960, 1962–75) of Laos. Educated as an engineer in France, he worked in Laos with the Public Works Service of Indochina from 1931 to 1950. He formed a coalition government with the Communist Pathet Lao forces in 1974 and was ousted by the Pathet Lao under his half brother SOUPHANOUVONG in December 1975.

sovereignty Sovereignty refers both to the powers exercised by an autonomous state in relation to other countries and to the supreme powers exercised by a state over its own members (see STATE, in political philosophy). In the context of international law, a sovereign state is independent and free from all external control; enjoys full legal equality with other states; governs its own territory; selects its own political, economic, and social systems; and has the power to enter into agreements with other nations, to exchange ambassadors, and to decide on war or peace. Although a sovereign state theoretically enjoys absolute freedom, its freedom is, in fact, often abridged by the need to coexist with other countries, as well as by treaties, international laws, and the strength of its military power. Sovereign power, which is the power to make and enforce the law and to control the nation's finances and military establishment, may be vested in one person (a monarchy, for example), in a small group of people (an oligarchy), or in all the people, either directly or through representatives (a democracy). It may be limited by natural or divine law, constitutions, or customs.

soviet The soviet, from the Russian word for "council," is the principal legislative and administrative unit in the USSR's formal power structure. Soviets operate at every level from villages to cities up to the Supreme Soviet, constitutionally the nation's highest legislative body. At lower levels, they supervise local enterprises and cultural affairs; at higher levels, they are usually legislative in nature. All deputies, or members of a soviet, carry out their duties in addition to holding full-time occupations.

Originally revolutionary workers' councils, soviets first emerged during the Revolution of 1905 and reappeared in the 1917 Revolution when the Petrograd (Leningrad) Soviet, led by Leon Trotsky, became an organ for the Bolsheviks' victory under the slogan "All Power to the Soviets."

Until recently, the soviets were in actuality the Communist party's instruments for implementing party policy. Recently, however, along with Mikhail Gorbachev's policy of glasnost (openness) and the erosion of the Communist party's monopoly of power, the soviets have been evolving into administrative units of the state.

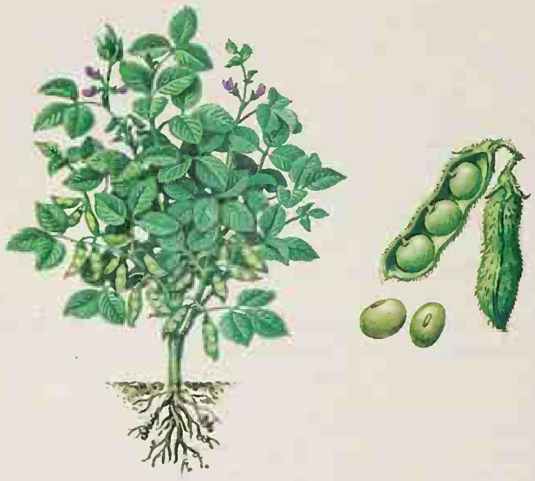
Soviet literature see RUSSIAN LITERATURE

Soviet Union see UNION OF SOVIET SOCIALIST REPUBLICS; RUSSIA/UNION OF SOVIET SOCIALIST REPUBLICS, HISTORY OF

Soweto [soh-way'-toh] Soweto (an acronym for South-Western Townships), on the outskirts of JOHANNESBURG, is the largest black urban complex in South Africa. The population, officially 868,580 (1980), has been estimated to be as high as 2.5 million (1987). The migration of blacks to urban areas has been strictly limited under APARTHEID, and Soweto is one of numerous planned communities developed with government funds to house South Africa's urban black population. Most housing is government owned. There is little industry, and most of the labor force commutes to work in Johannesburg. On June 16, 1976, students in Soweto protesting the imposition of Afrikaans as the language of instruction in black schools were fired upon by police, setting off months of violence in which hundreds of people died. The Soweto uprising came to symbolize black aspirations and white repression.

soybean The soybean, *Glycine max*, is a leguminous crop grown in many parts of the world and is of great economic significance as a source of edible oil and of high-protein foods and stockfeed. It is a cultigen (a species created through cultivation) and is not known in the wild. Its wild ancestor is believed to be *G. ussuriensis*, a rambling vine native to northeastern Asia. Like many leguminous crops, the soybean has lost the winding and climbing growth pattern of its wild relatives. It is an erect, bushy herb growing to a height of 30–90 cm (1–3 ft) and developing a profusion of roots that may reach up to a meter or more (3–4 ft) in loose soils.

Cultivation and Characteristics. Soybeans do not tolerate frost and are photoperiod-sensitive, which means that flowering cannot begin until summer nights grow longer. Plants require abundant moisture and, in the absence of irrigation, do not do well in areas of winter precipitation such as Europe and Pacific America. Soybeans can be grown in nearly all types of soil but do best in fertile loams. Depending on the variety, soybean plants mature in 75 to 200 days. When used as a green manure, the plants are plowed under while still green. When used as hay, the soybeans are cut before they are completely ripe. After the leaves fall and the pods and stems dry naturally, the seeds are harvested with combines. Soybean seeds are hard, generally yellow, and pea-shaped.



The soybean, one of the most important agricultural crops in the world, has ovate leaflets in groups of three, pink or purple flowers, and pods that contain one to three beans. A major source of protein, the beans are eaten fresh, made into meal, or processed into oil.

Uses. Soybeans are an important human food because they are unusually complete in proteins: of the eight essential amino acids, soybeans contain seven in sufficient quantity and are deficient only in methionine, which can be supplied from wheat or corn. Soybeans are eaten in numerous ways—as a green or dried bean and as the constituent of soy milk, curds, cheese, and various sauces—and are a major source of vegetable oil. Soybean protein is increasingly used as a meat imitation, or meat substitute. Soybean products are also important in animal feeds, and the green crop is used for hay, for forage, and as a fertilizer. Industrial uses include the manufacture of glycerin, paints, soaps, linoleum, rubber substitutes, plastics, and printing ink.

In the United States, almost half of the soybean oil produced is used in margarine and shortening, and another 20% is used to make other food products. Almost all of the soybean meal, the high-protein residue from the processing of soybean oil, is used to feed poultry and livestock.

Principal Areas of Cultivation. The world's four major national producers of soybeans are the United States, which produces about 65% of the world crop, and Brazil, China, and Argentina, which together account for nearly one-third of the world's production.

Soyer brothers [soy'-ur] The twins Raphael and Moses Soyer, b. Russia, Dec. 25 (N.S.), 1899, rank among the most important American figurative painters of the 20th century. They attended art classes at Cooper Union and, later, at the National Academy of Design, along with Ben Shahn, Paul Cadmus, and the future art historian Meyer Schapiro. Always painting what they knew best, the brothers produced numerous portraits of themselves and their friends as well as scenes of the city life around them. Noted for sympathetic honesty, they never painted types but always presented the individual. Moses died on Sept. 2, 1974, and Raphael on Nov. 4, 1987.

Soyinka, Wole [shaw-yin'-kah, woh'-le] Wole Soyinka, b. Nigeria, July 13, 1934, is perhaps the foremost English-language poet and certainly the most celebrated playwright of black Africa. His work earned him the 1986 Nobel Prize for literature. Combining Western dramatic forms with the music, dance, and mime of Africa, his plays achieve a ritualistic power and demonstrate the fundamental African concern with "numinous" boundaries: those between the human and the divine, between life and death.

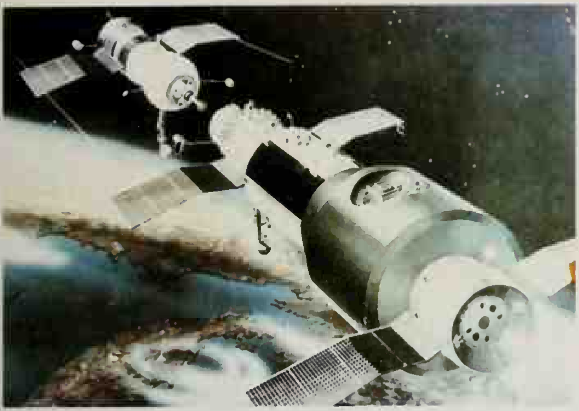
Since his first play, *The Swamp Dwellers* (1958), two volumes of his collected plays have been published (1973, 1974), as well as such later plays as *Death and the King's Horseman* (1975), *Opera Wonyosi* (1979), and *A Play of Giants* (1984). His verse includes *Idanre and Other Poems* (1967) and *A Shuttle in the Crypt* (1972), a set of poems composed during a two-year term (1967–69) in a Nigerian prison. Soyinka has written fiction (*The Interpreters,* 1965; *Season of Anomy,* 1973), literary commentary (*Myth, Literature, and the African World,* 1976), and memoirs (*Aké: The Years of Childhood,* 1982; *Isara*, 1989).

Wole Soyinka, a Nigerian dramatist, won the 1986 Nobel Prize for literature.

Photo Jill Krementz © 1974

Soyuz [soh-yoos'] The Soviet manned spacecraft Soyuz, in service since 1967, has been used in a wide variety of missions.

Missions. Western observers believe that the first manned Soyuz mission (Apr. 23, 1967) was to have involved a spectacular linkup between two spacecraft launched separately, followed by a space walk of two cosmonauts from one craft to the other. Instead, *Soyuz 1* was called back to Earth because of some malfunction, and its pilot, Vladimir Komarov, was killed in a landing mishap. After two years of unmanned and manned test flights, the two-craft docking and spacewalk eventually



A Soyuz spacecraft (upper left) *is depicted as it approaches a Salyut space station* (lower right) *for docking, after which the cosmonauts in the Soyuz board the Salyut.*

succeeded in January 1969, when *Soyuz 4* linked up with *Soyuz 5* and two cosmonauts from the latter transferred via a spacewalk to *Soyuz 4*. In response to the *Apollo 11* Moon-landing success, Soviet space engineers launched *Soyuz 6, 7,* and *8* on Oct. 11, 12, and 13, 1969, carrying out a series of maneuvering experiments of uncertain success. For the APOLLO-SOYUZ TEST PROJECT, *Soyuz 16* (1974) was a dress rehearsal for the *Soyuz 19* (1975) linkup with Apollo.

Along with the Earth-orbital missions, modified unmanned Soyuz capsules were launched (under the ZOND program) around the Moon in September and November 1968, and plans evidently were made to send a cosmonaut around the Moon early in 1969. These plans were canceled because of the unexpectedly rapid progress of the Apollo program.

Since 1971, Soyuz spacecraft have been used primarily to ferry crews and supplies between the Earth and the Soviet space stations (see SALYUT). A modified version of Soyuz, called Progress, with cosmonaut equipment replaced by fuel and cargo, has resupplied the Salyut stations on a steady basis since 1978 and is now doing so for the *Mir* station launched in 1986.

The Spacecraft. The 7-ton Soyuz consists of three primary sections: a conical command module, in which the crew rides during launch and landing; a cylindrical equipment module, attached aft of the command module, which contains electrical power equipment and rocket engines; and a spherical so-called orbital module, attached forward of the command module, which provides additional working space. Soyuz ships that are to link up with Salyut space stations have docking equipment on the front of the orbital module and are powered by batteries; Soyuz ships intended for independent flight are powered by solar panels. The Soyuz spacecraft was flown initially by as many as three cosmonauts, but the deaths of the *Soyuz 11* crew led to the introduction of new safety equipment that squeezed out room for a third crew member. An improved Soyuz, the T model, introduced in 1979, heralded a return to a larger crew size. A further improved TM model, first flown on a mission in 1987, contains improved navigation and docking equipment.

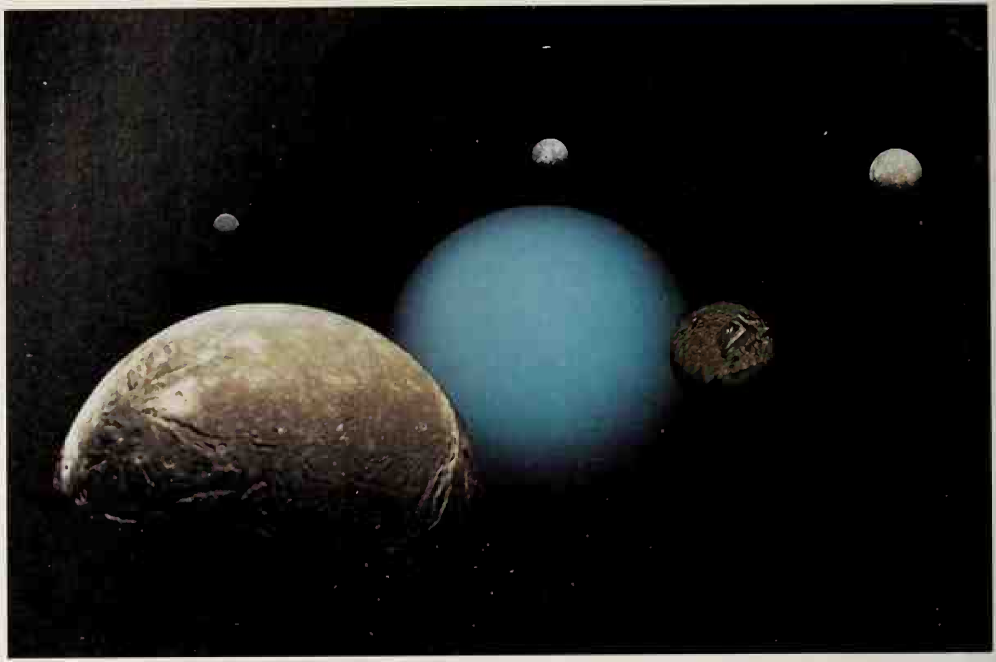
Launch occurs from the BAIKONUR COSMODROME on a Soviet booster called the A-2, an improved version of a similarly designed vehicle that launched the Sputnik satellites and the earlier Vostok manned spacecraft. In the event of booster malfunction, as with *Soyuz T10-A*, a solid-fuel launch tower pulls the Soyuz away from the rocket.

Spaak, Paul Henri [spahk] The Belgian statesman Paul Henri Spaak, b. Jan. 25, 1899, d. July 31, 1972, was a founder of Benelux—an economic union of Belgium, the Netherlands, and Luxembourg—and a leader of numerous international organizations; in 1946 he was the first president of the United Nations General Assembly. A Socialist, he was elected to the Belgian Chamber of Deputies in 1932 and retained his seat almost continuously—except for his term as secretary-general of NATO (1957–61)—until 1966. He served repeatedly as prime minister (1938–39, 1946, 1947–49) and foreign minister (1936–39, 1946–49, 1954–57, 1961–66). After World War II, Spaak's strong nationalism gave way to advocacy of European unity in the face of Soviet pressure. He chaired the European Economic Community (1948–50) and the European Coal and Steel Community (1952–54), earning the nickname "Mr. Europe."

space exploration The age of space exploration opened in the sixth decade of the 20th century. In the few years since that time, robot probes and then human beings first ventured beyond the limits of the Earth's atmosphere and landed on another celestial object, the Moon. Probes have since gone on to explore the far realms of the solar system and beyond.

Although the space age is still young, it is based on a long history of theoretical and practical developments. Long before the enabling technology for entering space was developed, a theoretical basis had been laid by science (see ASTRONAUTICS). The key to space exploration, however, lay in the production of the rocket engine (see ROCKETS AND MISSILES), which made possible the lofting of objects beyond the Earth's atmosphere. Once that was achieved, supporting technologies combined to yield the broad range of activities now being pursued in the realm of space. Such technologies include the development of scientific instruments to sense the conditions and processes found in outer space and to observe the objects encountered there, as well as the development of the transportation and communications hardware to support these activities. In order for human beings to survive in space, the effects of the vacuum, microgravity, and radiation conditions of that environment had to be studied as well (see SPACE MEDICINE), and the appropriate LIFE-SUPPORT SYSTEMS developed to meet those conditions.

Space exploration today includes the investigation of celestial objects ranging in size from cosmic dust to the giant planets of the solar system and the Sun itself. The



In the few decades since the space age began, probes have already reached the far regions of the solar system. The planet Uranus and its five major moons were photographed by the U.S. Voyager *2 probe early in 1986. This montage shows the blue planet* (center) *and* (in order of decreasing picture size) *Ariel, Miranda, Titania, Oberon, and Umbriel. The montage does not reflect the true relative sizes of planet and moons or their true orbital relationships.*

conditions encountered in outer space also alter familiar terrestrial processes, from simple chemical reactions to complex biological activities, and such effects are being explored to determine how they might prove useful, as in crystallization and drug purification processes. In addition, objects placed in orbit around the Earth provide platforms both for astronomical studies and for a wide range of scientific and practical activities relating to the Earth's surface, including surveys of resources, studies of weather processes, and the relaying of communications and television images between distant points. All of these subject areas lie within the field of space exploration. This article covers the general technical and policy issues of space exploration. Other articles on individual satellites, probes, and manned space programs treat specific achievements, as does the article on SPACE PROGRAMS, NATIONAL.

Basic Rocket Technology

The basic principle of a rocket engine is that when fuel is burned in the engine, the reaction mass is expelled at high speed and pushes the engine in the opposite direction, in accordance with Isaac Newton's law of action and reaction. The energy to expel the reaction mass usually comes from some sort of exothermic (heat-producing) chemical reaction that causes the combustion products to expand violently and to stream out of a nozzle. In chemical reactions the actual reaction mass is usually the combustion products of the reaction. A number of other types of rocket engines are also possible, including ion engines using electrically charged ions.

Thrust. The thrust, or "push," of a rocket engine is measured either in units of weight (kilograms or pounds)—where one unit of thrust gives to the equivalent unit of weight an acceleration of one gravity, or *g* (9.8 m/sec/sec, or 32.2 ft/sec/sec)—or, more properly, in newtons. A newton is a unit of force that gives one kilogram an acceleration of one meter per second per second. For any rocket, thrust in kilograms can be converted to force in newtons by multiplying thrust by *g*. Large values are measured in kilonewtons.

Efficiency. The efficiency of a rocket engine is a much more crucial indicator of its performance. Efficiency is measured by a quantity called specific impulse (I_{sp}), which is equivalent to the propellant's exhaust velocity divided by *g*. The resulting unit of measure is seconds. An equivalent concept is that the I_{sp} value is the duration of time for which one kilogram of propellant can produce one kilogram of thrust. The higher the exhaust velocity and specific impulse of a rocket engine are, the more efficient it is. Solid-fuel rocket engines tend to have I_{sp} values of up to about 200. Simple liquid-rocket systems, such as those using kerosene and liquid oxygen, have I_{sp} values that measure in the mid-200s. Hypergolic systems such as those using hydrazine and nitrogen tetroxide, where the components ignite upon contact, have I_{sp} values exceeding 300. Cryogenic hydrogen fuel can deliver values in the mid-400s. A simple nuclear engine such as the NERVA project of the National Aeronautics and Space Administration (NASA) in 1970 can deliver 800 to 900 seconds, but with significant complications in safety.

Staging. Rocket staging is also required in order to create vehicles of sufficient power for spaceflight. When most of a rocket's fuel has been exhausted, the rocket is carrying a great deal of empty-casing weight and is using a rocket engine whose thrust has become much too great for the remaining vehicle weight. Schemes were therefore developed to discard empty tanks and large engines during the course of a rocket's ascent. The simplest technique was to place an entire smaller rocket on top of a larger one; this is called tandem staging. Other approaches involve the use of side-mounted engines or even engine and tank assemblies than can be discarded in flight; this is known as parallel staging.

Mission Phases

A typical space-exploration mission requires, first of all, that a vehicle be launched from the Earth's surface into outer space. The vehicle must be able to survive and operate in space, after which it is sometimes returned to Earth. Each of these mission phases has specific challenges that must be met by space scientists and engineers.

Launch. The initial phase of launch must use engines with high thrust and compact fuel. In practice, the launch engine involves either kerosene/liquid oxygen or solid-fuel boosters. As a booster pushes against air resistance and the tug of gravity, it loses much of its energy during the ascent. By the time it has achieved orbital altitude and velocity, more than 160 km (100 mi) above the Earth's surface and moving horizontally at about 7,600 m/sec (25,000 ft/sec), the booster must have expended about 9,100 m/sec (30,000 ft/sec) of velocity gain. This generally takes about 8 or 9 minutes, for an average acceleration of 2 *g*s.

Satellites commonly enter orbit close to Earth, and this region of space is referred to as low Earth orbit, or LEO. Propulsive stages can carry the payload higher, or into the 24-hour geosynchronous orbit, or GEO, commonly used by communications and weather satellites because they keep the satellites in position above a selected point on the Earth's surface. Alternatively, an upper stage on a rocket can fire to push a payload to ESCAPE VELOCITY, or the velocity needed if an object is to effectively escape the Earth's gravitational influence. Escape velocity from Earth is about 10,800 m/sec (35,000 ft/sec). Vehicles departing from Earth are slowed by the tug of gravity, but as they attain greater and greater distances from the Earth, the gravitational pull decreases by the inverse square law (see GRAVITATION). Ultimately, a probe launched with the exact velocity for escape from Earth would reach an infinite distance with no speed left. In practice, vehicles are effectively out of Earth's influence at a distance of about 1,600,000 km (1,000,000 mi). At this distance they would drift in orbit about the Sun near Earth's own orbit.

In order to reach another planet, a vehicle must have a velocity that exceeds escape velocity. Added to or subtracted from the Earth's own orbital velocity around the Sun, depending on the direction of aim, this excess velocity produces a new interplanetary orbit that may intersect the orbit of the intended target. With proper timing of the launch—the so-called launch "window"—a target planet will be at the point where such an interception can occur.

Inflight Operations. The inflight operations of a spacecraft involve guidance, navigation, and control. In space usage, these terms have specific meanings. Guidance refers to the determination of which way a probe should go to achieve a desired end position, such as a planetary intercept or a rendezvous with another vehicle. Navigation refers to the process of determining exactly where a probe is at any given time, and where it will be later along that same course. Control refers to means of altering the flight path of a probe, usually by firing small rockets.

Guidance is accomplished by computing a space vehicle's end position compared to a desired condition, and then using the differences to determine what changes in current motion would result in smaller final differences. The future position is computed by propagating the vehicle's "state vector" (current position and velocity) forward in time, taking all gravitational influences into account as well as smaller perturbations due to atmospheric drag, solar wind, spacecraft venting, and similar disturbances. Significant course deviations can also be introduced by

The Saturn V launch vehicle, shown lifting Apollo 11 *into space in 1969 for the first manned landing on the Moon, used 11 rocket engines in a series of 3 stages. It is the largest booster developed by the U.S. space program.*

Early Bird (Intelsat I) *was the world's first commercial communications satellite. The outer cylindrical surface was covered with 6,000 solar cells that converted sunlight energy into electrical energy to power the satellite's 240 two-way voice circuits. It was launched on Apr. 6, 1965, into a geosynchronous orbit at an altitude of about 36,000 km (22,400 mi).*

imprecise launch-vehicle performance. A certain amount of state-vector dispersion must be expected due to imperfect executions of maneuvers.

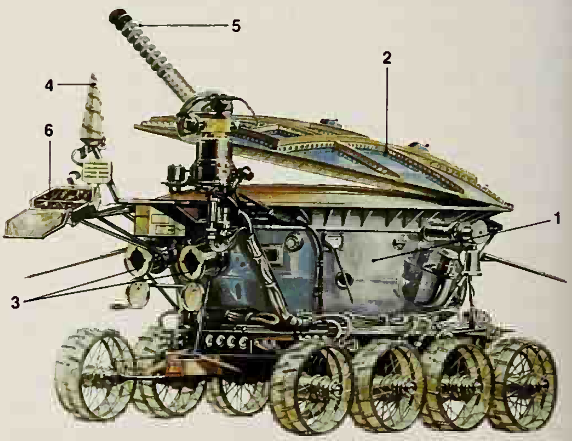
Measuring a space vehicle's actual position is a complex task. Powerful radar stations on Earth can track satellites out to several thousand kilometers by bouncing radar beams off them. Some satellites have transponders that automatically echo such a transmitted pulse, which greatly facilitates tracking. Satellites in GEO usually can be detected from Earth only by their own radio transmissions, however, by optical tracking through powerful telescope cameras, or by very powerful radar pulses to limited regions of interest. For deep-space vehicles, tracking is accomplished by analysis of returned radio signals, in terms both of line-of-sight to the probe and of Doppler shifts (see DOPPLER EFFECT) of the signal from the probe as it passes through changing gravitational fields. These measurements are compared to computer models of where the probe would be traveling if a certain initial position were assumed. From this comparison, a best estimate of position can then be determined.

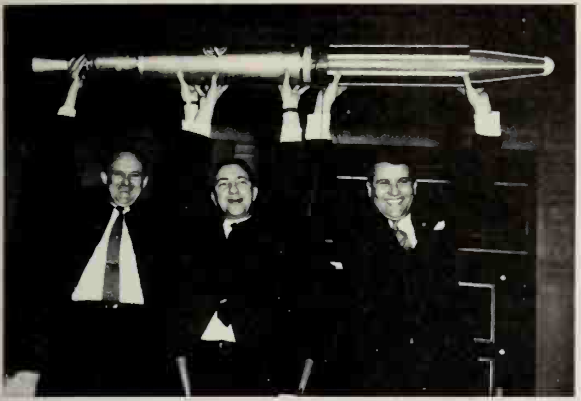
A space vehicle's own attitude, or pointing direction, is determined onboard. Precise angles can be measured relative to an outside inertial frame of reference by means of periodic star sightings, and GYROSCOPES are used to measure any variations that occur subsequently. A precise knowledge of attitude is required to perform proper course changes. Once required velocity changes have been computed, the vehicle must rotate itself in space in order to point its propulsion system in the proper direction, and then perform the firing at the precise moment for which it was computed. The velocity change actually executed can be observed by accelerometers on the probe. Following such correction maneuvers, additional periods of tracking may occur so that more navigation can refine the knowledge of the probe's trajectory and end point, and additional course corrections can then be performed as needed (see NAVIGATION).

Radio communications are required to command a probe and to receive information about its status and about the findings of its instruments. Information received over a radio link is called TELEMETRY. Control is exercised by sending coded instructions that are received by the spacecraft, interpreted by a circuit called the command decoder, and then executed as necessary by the probe's computer autopilot. For deep-space probes, the round-trip time of radio signals can become excessive. Round-trip time to the Moon, for example, is only a matter of seconds, but it can reach tens of minutes for Mars probes and many hours for probes in the outer solar system. Direct real-time commanding therefore cannot always be accomplished, and a great deal of flexibility and anticipatory programs are involved in preparing for such distant probes.

The use of ground TRACKING STATIONS is very different for LEO satellites and for deep-space vehicles. The latter move through the Earth's sky very slowly and can remain in sight of a single tracking site for up to 12 hours. Because of the low altitude and relatively great speed of LEO satellites, however, they quickly cross the sky of any ground site, moving from horizon to horizon in five or six minutes. This explains why satellites near Earth spend most of their time out of radio contact even though 10 to 20 tracking sites are available for use, whereas vehicles millions of kilometers out in space can be continuously monitored by only a handful of sites strategically spread around the globe. NASA's deep-space network has three main sites, at Goldstone in California, Madrid in Spain, and near Canberra in Australia. In order to overcome this geographical restriction and to reduce the expenses associated with maintaining worldwide radio stations, both NASA and the Soviet space program have been develop-

The Soviet Union's Lunokhod was sent to roam the lunar surface under remote control from Earth, providing television images and analyzing rocks and soil. Two such vehicles reached the Moon, in 1970 and 1973, carried by Luna 17 *and* Luna 21. *The body* (1), *a pressurized compartment for instruments, was covered by a hinged solar array* (2), *which could be raised. The Lunokhod had two television cameras* (3), *an omnidirectional antenna* (4), *a narrow-beam directional antenna* (5), *and a laser reflector* (6) *for determining the Moon's distance.*





A replica of Explorer 1, *the first U.S. artificial satellite, is held aloft by launch-team members* (left to right) *William Pickering, James Van Allen, and Wernher von Braun.*

ing geosynchronous relay satellites. Known in the United States as the Tracking and Data Relay Satellite System (TDRSS), the network of two satellites and one spare is supposed to relay near-continuous data from manned and some unmanned satellite missions. The equivalent Soviet system is called Luch ("ray"). Once operational, such relay satellites could eliminate the need for the string of worldwide tracking sites that are now devoted to LEO payloads.

Electrical power is another feature common to all space vehicles. Probes on missions lasting only a few days may use batteries or high-efficiency fuel cells that convert cryogenic oxygen and hydrogen reactions into electricity, with water as a waste product. Solar cells, arranged either in flat panels, or "wings," or wrapped around the outer surface of a probe, are the most common power source. They must be supplemented by batteries, however, for those times when spacecraft pass through planetary shadows. For missions to Jupiter and beyond, where sunlight is only a few percent as great as near Earth, solar energy is too weak. In such cases small nuclear devices are used—thermoelectric systems in which the heat from radioactive decay is converted by thermocouples into electricity. Full-fledged nuclear reactors have also been used in LEO, where large power output is required from compact units. The most notable example is the Soviet radar ocean surveillance program, in which two satellites and their reactors have fallen to Earth, one in 1978 and the other in 1983.

Return to Earth. For spacecraft that are to be returned to Earth, a controlled descent is required. This is initiated by a "deorbit" maneuver that uses onboard propulsion to slow the vehicle's speed by about 1 percent. This slight amount is sufficient to lower the orbital path into the upper atmosphere, where drag will slow it further.

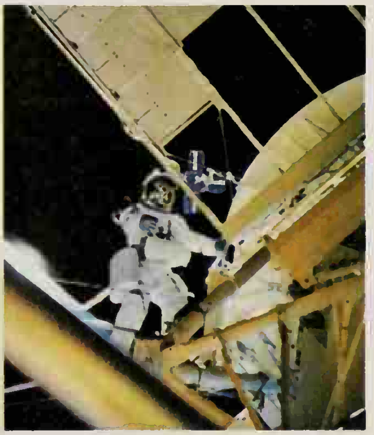
Entry into the atmosphere poses special craft-survival problems. Tremendous heat builds up, not on the skin of the vehicle (friction is not involved) but just ahead of it, where a shock wave creates severe air compression. The resulting plasma (see PLASMA PHYSICS) can reach temperatures as high as on the surface of the Sun. This heat will soak into the vehicle unless it is shielded, either by an ablative covering that carries heat away as it boils off, by a very efficient insulator such as the material used in the SPACE SHUTTLE tiles, or by an active cooling system. Atmospheric resistance slows the vehicle sharply, creating deceleration forces of up to ten times the force of gravity. Superheated air becomes ionized and surrounds the vehicle with a sheath that blocks all radio communications. These effects require a precisely guided descent profile to enable a safe return.

The Space Environment

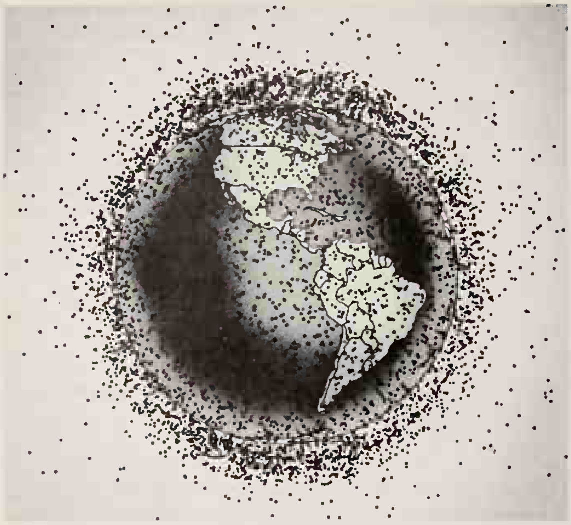
One of the first discoveries made by early Earth satellites was that an unexpectedly high number of charged particles were trapped in the Earth's magnetic field. Soviet instruments had earlier detected hints of this, but it was the U.S. *Explorer 1* satellite that helped determine that the Earth is encircled by what are now known as the VAN ALLEN RADIATION BELTS—named for the scientist who designed the instruments aboard *Explorer 1* and properly interpreted the readings. Other characteristics of the space environment, some anticipated and some unexpected, were also experienced by these early probes. Such characteristics include a very hard (that is, relatively very pure) vacuum, so-called zero gravity, high solar illumination levels, radiation, and micrometeorite hazards.

The vacuum conditions encountered in space required the encapsulation of apparatuses and passengers in a space vehicle, or else the special and expensive design of equipment that could work without an air environment. The cooling of electronics systems became a problem, and moving parts required special lubricating systems because they otherwise tended to stick together when operating in space.

The free fall of satellites in low Earth orbits created the condition commonly called zero gravity. Technically, this term is a misnomer. The force of gravity in low Earth orbits is scarcely diminished from that experienced at the Earth's surface; it is the motion of the satellite that re-



U.S. astronaut Owen Garriott installs an experiment outside Skylab *in 1973 during the third mission to the station. By that time scientists knew that in low orbits such as* Skylab's, *such environmental hazards as radiation were not sufficiently high to cause concern during short periods of extravehicular activity by humans.*



This computer-generated picture shows the nearly 7,000 objects of baseball size or larger that were being tracked in Earth orbit by the late 1980s. Orbiting "junk" is a concern for future space missions.

sults in the effect of weightlessness. The term "zero-G" has passed into common usage, however, and is going to remain in writings about space. Because slight accelerations actually do occur even on a satellite—due mainly to air drag and satellite motion—the more recent term *microgravity* has generally been adopted as well.

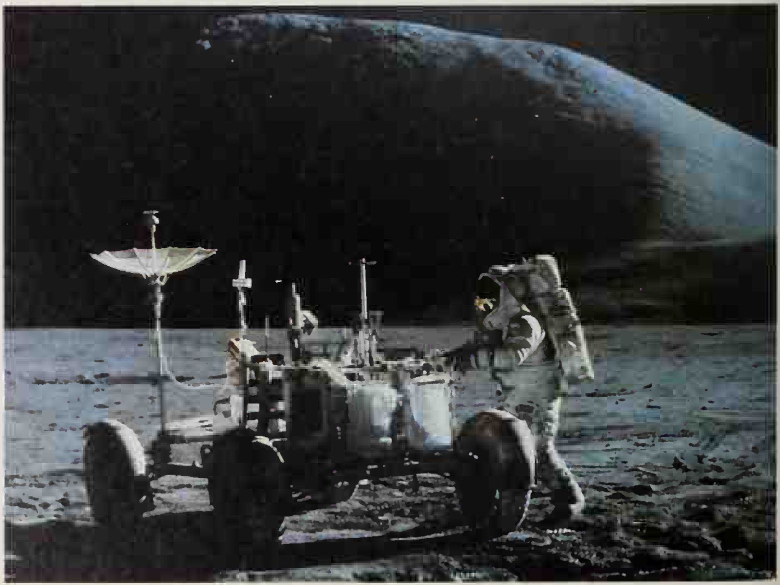
Unfiltered solar radiation can cause illuminated portions of a spacecraft to rise to high temperatures. Meanwhile, shaded portions of the craft will radiate their warmth into space and cool below the freezing point of common fluids such as water and storable rocket fuels. All such fluid containers and lines are commonly equipped with electrical heaters, while overall temperatures are moderated by rotating the spacecraft along an axis perpendicular to the spacecraft-Sun line. This is known as passive thermal control, or, more colorfully, "barbecue mode." Unmanned spacecraft to the inner planets must be equipped with parasols to reflect away unwanted solar heat. Those sent to the outer solar system—or to the Moon's surface, with its two-week-long nights—often use radioisotope heaters (see SNAP).

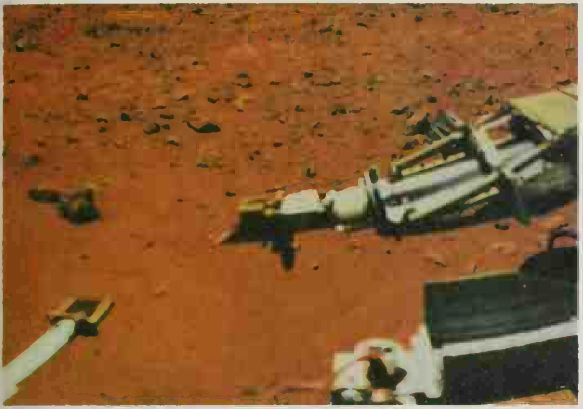
Radiation effects on spaceflights also took some time to appreciate. Satellites in LEO are protected by the magnetosphere from solar charged particles and from a large percentage of the cosmic rays arriving from outer space. Vehicles operating at GEO or on interplanetary missions, however, receive the full force of these radiations. Cosmic rays have been known to penetrate integrated circuits in spacecraft autopilots and to alter data and commands. A space version of static electricity has built up on other space vehicles during solar storms, resulting in electrical sparks that caused severe problems in onboard electronics. Redesign of such systems has reduced the effects of these influences.

The danger from micrometeorites, on the other hand, has proved to be slight. Although numerous impacts have been recorded—and, on at least one occasion, actually

(Above) *Neil Armstrong, the first man on the Moon, took this picture of Edwin Aldrin, Jr., on the lunar surface on July 20, 1969.*

(Below) *The first Lunar Rover was taken to the Moon by the* Apollo 15 *astronauts and driven 28 km (17.4 mi) during their search for rock samples. James B. Irwin, working beside the Rover, is picking up rocks with a lunar scoop.*





A July 1976 view of the Martian surface at the Viking 1 *landing site discloses a red plain strewn with angular rocks. The extendable sampler scoop dug trenches near the spacecraft to obtain samples.*

Mercury was photographed during three successive passes by the Mariner 10 *space probe in 1974 and 1975. While the heavily cratered surface resembles that of the Moon, it also shows unique features such as long, winding ridges.*

heard by an orbiting crew—no spacecraft is known to have been seriously damaged by such particles. Debris from other artificial satellites appears to be increasing as a significant danger, however, and one Soviet satellite may actually have been destroyed by such a collision with "space junk."

Policy Issues

Several major policy questions are involved in planning for the future. Such questions deal with the matter of international cooperation as opposed to international competition, the desirability of manned versus unmanned activities in space, the issue of long-range planning, the employment of reusable versus expendable systems, and problems relating to space industrialization and the orbiting of military systems.

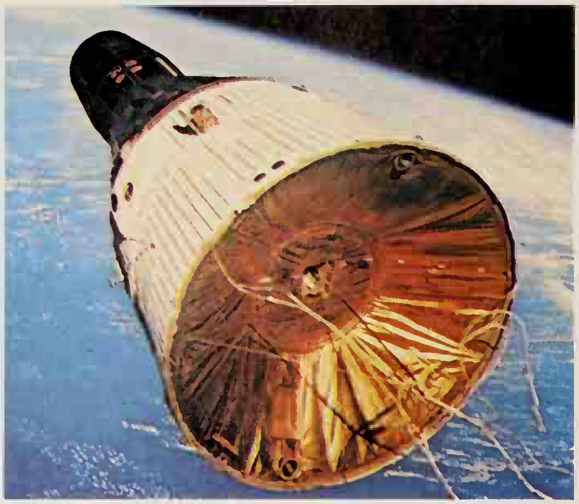
Because most nations who fund space exploration do so in order to accrue national benefits—whether technological, military, or simply in national prestige—the development of international cooperation has long been balanced against concerns for such national benefits. It should be observed that many international space projects, such as Spacelab, Ariane, Vega, and Kvant, have proved particularly successful because each nation involved has contributed in its own areas of specialization. Such alliances have yielded large amounts of knowledge that could then be shared satisfactorily—as could the prestige involved, as well.

The costliness of manned space activities has fueled the ongoing dispute over the desirability of involving astronauts and cosmonauts in operations that can also be conducted automatically by means of remote control. Many tasks of space exploration are in fact best performed by unmanned systems, but the most complex and unpredictable operations often exceed the capacity of computers and telemetric systems and instead require the presence of flexible, perceptive, imaginative humans. Experience on Earth has demonstrated that the most valuable discoveries in exploration and research are often those which were completely unexpected, and hence those which unmanned systems might overlook.

Long-range planning for space exploration is bedeviled with the down-to-earth problems of political and budgetary support. Despite the general desire for consistent levels of space funding, nations customarily do not plan budgets for decades in advance. National interest in space activities also waxes and wanes with dramatic short-term variations, based on opportunities that arise for the achievement of relatively short-term goals. Major space projects in the United States, at least, have tended to take place in sprints, with long pauses in between, and realistically speaking, they will probably continue to do so.

The high cost of space exploration has led to major efforts to economize, and this in turn has created the conflict between reusable and expendable spacecraft sys-

Infrared photographs of Earth from space by means of such satellites as Landsat have provided vast amounts of new information on resources, land use, and pollution hazards. Surfaces can be given color values according to how they absorb infrared light. Thus, in this photo, water appears deep blue and vegetation bright red.



Gemini missions provided astronauts with training in a larger, more advanced craft than Mercury. This view of Gemini 7 *from* Gemini 6 *was taken Dec. 15, 1965, during the first rendezvous by U.S. craft.*

tems, primarily in the area of launch vehicles. The issue is complicated by the fact that the largest costs of space operations usually are not for the hardware but instead for mission checkout, preparation, and management, and these costs may actually be increased if the space vehicle being prepared has already been used several times. In addition, reusable space systems must sacrifice a significant portion of their performance in order to include recovery aids, such as wings or parachutes. Thus, "throwaway" systems may actually be cheaper to operate, pending the development of advanced space vehicles that can be recycled economically.

The promise of space industrialization remains thus far unrealized, because of the continuing high cost of space operations—primarily in the area of transportation—and because ground industrial technologies also continue to advance. The high start-up costs for the space industry, combined with the excessively long lead times between investment and payoff, have been major factors in discouraging the development of such projects by private Western corporations. Clearly, however, a number of high-value and low-volume products such as crystals, drugs, and glass could be manufactured in space at an advantage, and the commercial sale of some products has already begun.

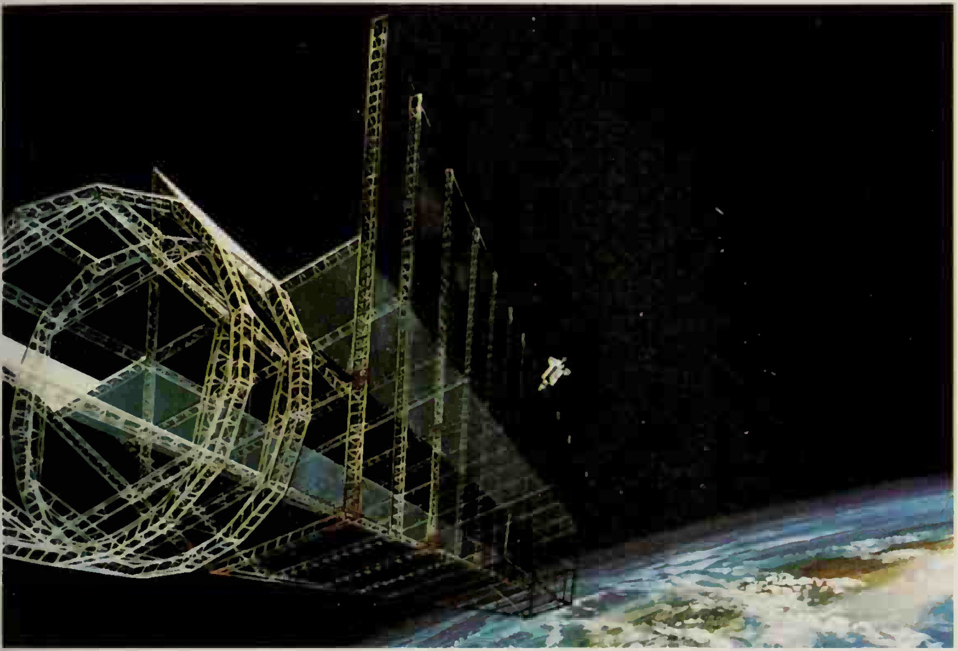
Few space-exploration issues are more emotional or have more diplomatic and ideological connotations than the conflict over space militarization versus treaty restrictions. Space is already a transit region for military missiles, and it has served as a vantage point for military reconnaissance since soon after Sputnik. Several limited antisatellite (ASAT) systems have also been developed, and the Soviet Union has an orbital "killer" satellite. Nevertheless, efforts to develop space-based weapons systems such as the U.S. STRATEGIC DEFENSE INITIATIVE program are considered by many to be excessive and inflammatory. Technical issues are poorly defined in this dispute, which is grounded mainly in political doctrines.

A Look to the Future

Among the possible projects over the next several decades in space are large-scale space colonization, the development of lunar bases for both scientific research and the exploitation of resources, and manned interplanetary flights to Mars and its small moons Phobos and Deimos. At the same time, new Earth-observation technologies will continue to be developed for the improved monitoring of the planet's lands, waters, and atmosphere. These technologies, which involve measurements in many areas of the electromagnetic spectrum as well as active radar studies from space, can also be applied to future SPACE STATIONS and probes. Unmanned interplanetary programs might involve probes into the Sun's outer atmosphere, orbiter/lander projects on Mercury, long-term atmospheric probes to Venus, a series of sample-return missions to Mars and the asteroids, and missions to comets and outer planets.

Returning to the Moon on a permanent basis is a serious option for the near future. The Moon also could provide an excellent base for deep-space observations using optical and radio telescopes. Oxygen, the major component of rocket propellants as well as a key element in life-support supplies, can be produced readily from the lunar soil. It may also prove feasible to obtain building materials from the lunar soil, ranging from metals to cinder

Astronaut David Scott begins a space walk from the Command Module of Apollo 9 *as James McDivitt and Russell Schweickert look on from the Lunar Module (LM).* Apollo 9 *was an Earth-orbit test flight of the LM that took place 4 months before the moon-landing mission of* Apollo 11 *in July 1969.*



In this artist's conception, a Space Shuttle approaches a large solar-power satellite under construction in orbit high above the Earth's surface. Such satellites would convert sunlight into electricity, which would then be beamed to Earth in the form of microwaves and reconverted to electricity.

blocks. Advanced "space tugs" would be adequate to provide transportation, but at least one near-Moon substation would have to be erected either in lunar orbit or at another suitable point for the support of efficient and flexible flight schedules between the Moon and Earth.

Manned missions to Mars require a number of technological capabilities that are now being developed for more immediate purposes. Heavy boosters will be required, and efficient and reliable transport systems such as the space tugs mentioned above must be developed. Beyond these and similar goals in space exploration lie far more imaginative and difficult adventures.

To send a probe from our solar system to a distant heavenly object, such as a star in another part of the Galaxy (inset), *engineers would have to design a rocket that could provide a relatively slow acceleration over a long period of time, rather than the short-lived high acceleration provided by current rockets. In the hypothetical photon rocket, such an acceleration would be produced by the ejection of a beam of light particles, or photons, created by the annihilation of matter and antimatter in the rocket engines.*

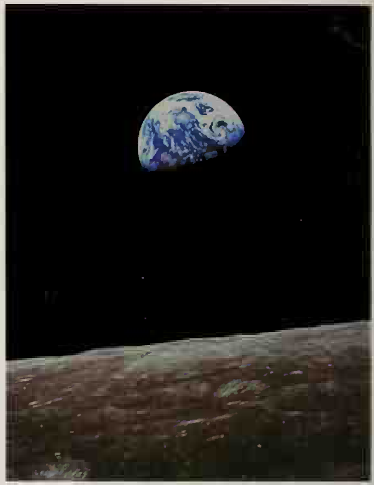
space exploration, commercial The wholly commercial exploitation of space was becoming a reality as the 20th century drew to a close. In the early years of SPACE EXPLORATION, all launch vehicles and satellites were the property of national governments, but in following years private corporations and institutions began developing their own satellites and experiment packages and financing their launches from government facilities. This became most notable in the field of COMMUNICATIONS SATELLITES, but many companies also began to explore remote-sensing and manufacturing possibilities in outer space (see SPOT, satellite).

Efforts toward commercialization intensified in the 1980s. The U.S. SPACE SHUTTLE was first conceived as a system that eventually would support many commercial launches, but this plan was canceled after the *Challenger* disaster of 1986. In the meantime a European marketing company, Arianespace (see ARIANE), was formed for commercial launching purposes, although it remained substantially subsidized by the French government. The Soviet Union, China, and Japan also entered the competition for launching commercial packages.

In the United States, in 1989, companies that had been manufacturing large launch vehicles for the government began to use unsold rockets for orbiting commercial satellites. In addition, several private companies were developing small sounding and launch-rocket fleets of their own. In fact, the first commercially licensed U.S. launch took place on Mar. 29, 1989, when Space Services Inc. of Texas sent aloft an instrument package on one of its sounding rockets. Although prospects for space commercialization remain clouded by many legal and governmental entanglements, this new era in the exploitation of space is now under way.

space law Space law is a field of international law concerned with the law applicable to exploration and use of outer space. With the launching of the first satellites in the 1950s, questions arose over the problem of sovereignty in space. Numerous resolutions of the UN General Assembly and five major international treaties took up these problems. Perhaps the most important treaty was the 1967 Outer Space Treaty. It stated that the Moon and all other celestial bodies were to be free for exploration and use by all states and that international law and the UN charter would apply. Signatories pledged not to place weapons of mass destruction, including nuclear weapons, in space or to establish military bases there. (The 1963 Nuclear Test Ban Treaty prohibited nuclear testing in outer space.)

The 1968 Treaty on the Rescue and Return of Astronauts, the 1972 Treaty on Outer Space Liability for Damage Caused by Space Objects, and the 1974 Treaty on Registration of Space Objects with the United Nations added to the growing body of space law. In the 1979 Moon Treaty, however, provisions regarding commercial mineral extraction on the Moon have aroused considerable controversy. The United States, among other nations, has not signed the treaty—perhaps out of concern that aspects of the law, such as required sharing of space technologies, may inhibit exploration.



As advanced nations draw nearer to the practical possibility of the exploitation of space resources, treaties such as the 1979 Moon Treaty are likely to become even more controversial and difficult to draw up without many reservations. This view of the Earth from the Moon was taken by Apollo 10 *in May 1969, shortly before humans walked on the Moon's surface for the first time.*

Advances in space technology are requiring further legal developments, particularly with the growing potential for commercial operations in space. The more mundane problems involved in such operations include the patenting of materials and processes that could be conceived and pursued on space stations, questions of civil liability and insurance, and matters of contracts and of export controls. In addition, U.S. efforts to develop a space-based defense system are also raising renewed questions over the militarization of outer space (see STRATEGIC DEFENSE INITIATIVE).

space medicine Space medicine is the branch of medicine involved in protecting human beings from the environment of space and, at the same time, studying their reactions to that environment. The foundations of space medicine can be traced back to aviation medicine, and the term *aerospace medicine* has evolved to encompass activity in both areas. Aerospace medicine has been a certified subspecialty of the American Board of Preventive Medicine since 1953. In addition to physicians, however, engineers, veterinarians, dentists, nurses, physiologists, psychologists, bacteriologists, toxicologists, pharmacologists, and biochemists also work in the field of space medicine. Specialists in space medicine are involved in all aspects of spaceflight, from spacecraft design and crew selection to flight operations and postflight review.

Environmental and Physiological Effects

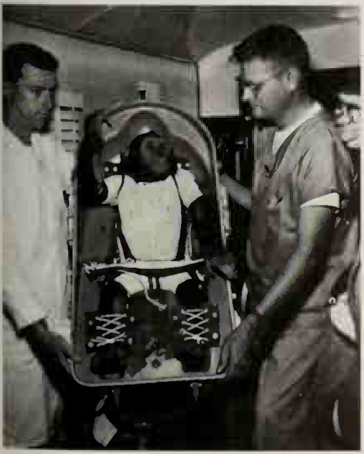
The physiological functions of human crews in space have been measured by a variety of means over the years, ranging from simple sensors placed on the body to monitor heart rate and respiration, to the use of techniques such as echocardiography and electroencephalography. The many thousands of hours of information thus gained on human activity in a weightless environment have proved that people can perform assigned tasks well and need suffer no permanent postflight physiological changes, even after missions lasting several months. To maintain an acceptable state of health, however, space crews do require an appropriate atmosphere, adequate food and hygiene facilities, exercise, a proper balance between work and rest periods, and sufficient time to acclimatize to space and also to the return to Earth.

Environmental Factors. The atmosphere, pressure, and temperature of spacecraft interiors are always strictly controlled in order to avoid serious or even fatal health hazards such as explosive decompression of the craft, the onset of decompression sickness (see BENDS), carbon dioxide narcosis, HYPOXIA, and other such problems. All materials used in or brought aboard spacecraft are tested beforehand for the potential release of toxic substances when in the spacecraft environment.

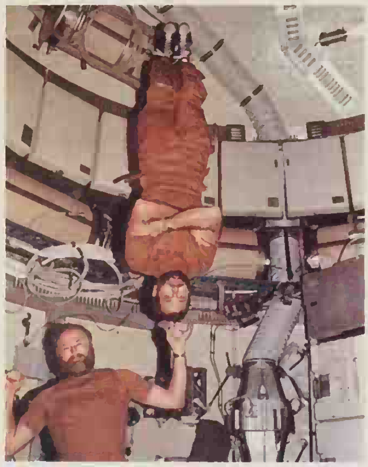
An important concern is the radiation encountered in space, since excessive exposure to such radiation can result in a greater likelihood of developing certain kinds of cancer. A crew's exposure to radiation depends on many factors: the type and length of the mission, the amount of shielding on the spacecraft, the relative altitude of the craft's orbit, and activity on the Sun during the period of flight. The average skin radiation dose received on the Apollo missions ranged from 0.16 to 1.14 rads (see RADIOACTIVITY), which is less than the dose received with some diagnostic X-ray procedures.

Another environmental concern is that of the natural circadian (24-hour) cycle of human body rhythms (see BIOLOGICAL CLOCK). These rhythms are maintained in the U.S. program by keeping the crews on Houston time, and in the Soviet program by keeping their crews on Moscow time. The Soviet Union has attempted to alter the circadian rhythms of their cosmonauts by having them awaken 20 minutes earlier on each day during a long-term flight, but such efforts have not proved successful and are no longer tried.

Short-Term Physiological Effects. In order to deal with the effects of increased gravity loading (g loading) during the acceleration of launch and deceleration of reentry, crews in both U.S. and Soviet spacecraft generally have been placed so that the g loads are experienced in the chest-to-back position rather than the head-to-foot position. The human body can withstand a much higher g loading in the former mode. The g loads themselves, which have varied from 3 to 8.2 times the gravity experienced at the Earth's surface, have created no problems. In the U.S. Space Shuttle, however, crews take a reentry decelerative force of about 1.5 g in a feet-first position, which causes blood to push toward the feet. To counteract this effect, Shuttle crews are provided with suits that produce pressure on the lower part of the body.



Ham, a 17-kg (37-lb) chimpanzee, is strapped into his seat before takeoff on a suborbital flight in a Mercury capsule on Jan. 31, 1961. Human beings were sent into space only after monkeys, dogs, and other animals proved capable of surviving in space without sustaining permanent physiological damage.



The freedom of weightlessness is experienced by American astronauts Charles "Pete" Conrad, Jr. (left), and Paul J. Weitz during the first manned Skylab flight in 1973. After a period of adjustment, astronauts lived comfortably in conditions of zero gravity for up to 84 days.

Physiological changes start to occur from the first moment of achieving orbit. Body fluids redistribute themselves toward the head. As they do, the face puffs out, and some astronauts experience sensations similar to those of a head cold. The intestines also tend to float upward, and as a result an astronaut may lose as much as 10 cm (4 in) in girth. The curve of the spine also straightens out somewhat, so that persons may gain an inch or so in height while in the weightless environment. Many astronauts have experienced a mild lower backache as a result of the different stresses being placed on the back muscles in space.

The vestibular system consists of the otolith and the semicircular canals of the inner ear—which constitute the body's organs of balance. When they are disturbed, MOTION SICKNESS can result. In space, this is known as "space adaptation syndrome." Its symptoms include pallor, cold sweating, mild dizziness, stomach nervousness, nausea, and vomiting. The symptoms can occur as early as an hour after launch or as late as the second day of flight, and they can persist for as long as four days. Approximately half of the male astronauts and cosmonauts have experienced these symptoms, and about 10 percent of the females. The causes of the syndrome are not yet known, and treatments thus far appear to have been either ineffective or only marginally effective. Because the symptoms disappear shortly, however, the disorder is adaptive and self-limiting.

Other physiological changes associated with short-term spaceflight include some cardiac deconditioning and a decrease in the volume of body fluids. These changes return to preflight norms within a short time.

Effects of Long-Term Spaceflight. Exposure to weightlessness for time periods exceeding about two weeks results in degenerative physiological effects similar to those of prolonged bedrest on Earth. If left unchecked, these changes could result in severe and perhaps even dangerous weakness. Because of this, several countermeasures are employed on long-duration flights to arrest the body's adaptation to the effortless weightless environment and to keep it fit enough to return safely to Earth. For example, certain muscles tend to atrophy through lack of use during weightlessness, and animal tests show that muscle tissue can also lose blood vessels and nerve associations. Studies also suggest that deterioration in muscle tissue may be accompanied by decreases in metabolic efficiency. An increase in food intake, combined with vigorous inflight exercise using a variety of equipment, can at least partially counteract muscle deterioration.

The redistribution of body fluids during weightlessness causes the body to eliminate some fluids in the urine. Tissues dehydrate to some degree, and the volume of blood plasma drops by about 10 percent in two weeks. The mass of red blood cells drops by 15 percent, and the shape of the cells also changes; their function, however, is not impaired. In fact, red-blood-cell mass appears to stabilize and recover after about 60 days of weightlessness, in most cases. These changes appear to be normal body adaptations to space conditions; countermeasures include increased water intake and exercise during the flight. After the return to Earth, body fluids return to preflight norms rapidly and blood counts return to normal within a few weeks.

The shift in body fluids and the decrease in blood volume, along with the absence of gravity, also reduce the size and pumping capacity of the heart. Exercise and adequate fluid intake are, again, the usual countermeasures used to avoid serious cardiac and circulatory problems. Most cardiovascular responses return to normal within a few weeks.

Loss of calcium from the weight-bearing bones of the body is apparently continuous throughout a flight. The loss is significant, ranging in various individuals from 0.5 percent to 1.5 percent total body calcium per month. Although several countermeasures have been tried, none have halted the decalcification process; exercise, however, does appear to slow down the rate of loss. Postflight recovery of lost calcium is a lengthy process, taking at least as long as the flight itself. Some bone loss may be irreversible, particularly in the beamlike network (trabeculae) of spongy BONE.

On very-long-duration Soviet flights, such changes have been observed as a rise in steroid hormones, damage to the T-lymphocytes, heightened sensitization to allergens, and increased vulnerability to staphylococcus and streptococcus infections. Such changes indicate possible changes in the body's immune system over long periods of time.

This space suit was designed by NASA for use during the space station program in the 1990s. Known as the Zero Prebreath Suit (ZPS), it allows astronauts to avoid the three to four hours of preparatory adjustment that has been required before going out in space from crew cabins at standard atmospheric pressures.

Special Hazards and Emergencies. Extravehicular activity (EVA), or spacewalking, poses a special health hazard. The astronaut or cosmonaut must rely on the perfect functioning of a spacesuit, and may have to experience changes of atmosphere and pressure between spacecraft cabin and spacesuit that can result in decompression sickness. In situations where cabin and spacesuit atmosphere and pressure are quite different, as in the U.S. Space Shuttle, lowered cabin pressure and prebreathing of oxygen prior to EVA is required. Few clearcut medical emergencies have thus far occurred in space, although various medical problems have been indicated.

Psychological Effects

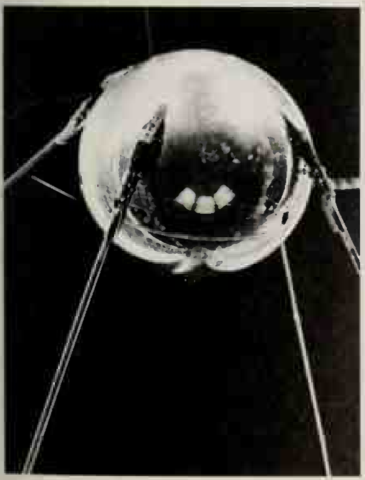
The psychological adaptability of humans to spaceflight conditions has been of great interest to the space programs concerned. Soviet scientists, in particular, have studied psychological matters in some detail during the lengthy occupations of their space stations. Their studies have included preflight crew-compatibility testing, voice stress analysis, and the elaborate psychological support of crews during actual flights.

Several stages of psychological adaptation to spaceflight may be elaborated. They include the period of intense and lengthy preflight training and testing; the period of heightened anxiety prior to and during launch; the approximately month-long period of adaptation to weightlessness and the establishment of an effective work-rest routine; the following period of midflight depression and fatigue that comes approximately four months into a flight; the anticipation of the flight's end (called "breakaway"), including excitement and uneasiness; the exhilaration and discomfort felt upon first return to Earth; and, finally, reintegration into the setting of family and accustomed routines. In a few cases—most notably some of the Apollo astronauts—crew members have exhibited a reassessment of their lives and changed direction after spaceflight.

A Look Toward the Future

Both the United States and the Soviet Union are seeking to develop permanent low-orbit SPACE STATIONS. Workers in space medicine are therefore focusing increased attention on the most crucial health issues involved: bone decalcification, changes in the immune system, heart and muscle deterioration, and long-term exposure to radiation. Animal experiments and studies of drug effectiveness in space will form an important part of such research. In addition, since both nations have expressed an interest in the possibility of interplanetary flights in the farther future, health problems relating to colonization of the Moon and exploration of Mars and its moons will undoubtedly play a larger part in future space-medicine programs. Such problems include the development of crew-selection criteria for flights of very long duration, and the maintenance of mental acuity and physical well-being during such prolonged periods of relative SENSORY DEPRIVATION. Maintaining the social health of small-scale societies on space stations and on severely isolated extraterrestrial outposts will present unique challenges.

space programs, national The space age dawned with the launching of SPUTNIK *1* by the Soviet Union on Oct. 4, 1957. Since that event many thousands of spacecraft have been placed into Earth orbit, and numerous probes have been launched on lunar, planetary, and cometary missions. Most of these craft have been launched by the United States and the USSR, with the Soviets accounting for more than 50% of all successful launches. Although the early years of the space age were characterized as a "space race" between the United States and the USSR, other nations quickly began developing their own domestic programs. Such activities soon transcended national boundaries. While the programs of a number of individual nations are described below, many nations do their most advanced work in alliance with other nations.



Sputnik 1, *the world's first artificial moon, was placed in Earth orbit by the Soviets on Oct. 4, 1957. The satellite, an aluminum sphere 58 cm (23 in) in diameter, had 4 antennas attached to it and weighed 84 kg (184 lb). It contained a radio transmitter and equipment used to monitor its internal temperature, to detect punctures by micrometeoroids, and to study the Earth's atmosphere.*

Yuri Gagarin, a Soviet cosmonaut, was the first human to orbit the Earth. He was launched into space on Apr. 12, 1961, aboard a Vostok spacecraft to a maximum altitude of 327 km (203 mi). After one orbit of the Earth, the spacecraft reentered the atmosphere and soft-landed on Russian soil. The entire flight lasted 1 hr 48 min.

Soviet Union

From its beginnings with the launch of *Sputnik 1*, the Soviet venture into space has been characterized both by a slow, steady progress and by a determined exploitation of the space environment to meet a broad spectrum of national goals. The Soviets possess a respectable array of spaceflight operational skills. With about a hundred space launches each year, a permanently manned space station, heavy space boosters, operational space weapons, and a bold program of interplanetary exploration, the nation in the late 20th century appeared ready to dominate the field. These highly visible strengths, however, were accompanied by some less obvious shortcomings that could temper such an evaluation.

Launch Facilities. The busiest Soviet spaceport is located at Plesetsk, north of Moscow. Built in 1960 as a base for military missiles, it was converted to space missions in 1966. Due to the primarily military nature of the orbital launches taking place there, the base's existence was officially unacknowledged until 1983, when an admission was prompted by widespread public anxiety in the region over mysterious lights in the sky—actually, satellite launchings from the base.

All manned Soviet space missions originate at the so-called BAIKONUR COSMODROME. Despite its name, the facility does not lie near the village of Baikonur but instead near the village of Tyuratam, just east of the Aral Sea in Kazakhstan. Tyuratam has been enveloped by a new town, named Leninsk, that houses the facility's personnel. Large booster rockets such as Proton and Energiya, in addition to all interplanetary missions, are also launched from Baikonur, as well as several special-purpose military missions.

A third, small launch facility is located at Kapustin Yar, on the lower Volga River. Although the base mainly performs sounding-rocket operations, occasional small-satellite launchings occur at the facility.

Launch Vehicles. The current stable of Soviet space launch vehicles consists of six distinct types of boosters, with variations within each class. Three different nomenclature schemes exist for classifying these vehicles: the USSR's own method, a letter code developed by the U.S. Congressional Research Service (CRS), and the once-

The cosmonaut Valentina Tereshkova, the first woman in space, made a 49-orbit flight in Vostok 6 *in June 1963.*

classified space launcher (SL) code of the U.S. Defense Intelligence Agency. While the SL scheme is the most complete, the CRS scheme includes indicators of relationships between several variants of the same design. The Soviet scheme uses the name of each booster's main payload, so that more information on Soviet launch vehicles may be found in such entries as PROTON and SOYUZ, as well as in the article ROCKETS AND MISSILES.

The long-awaited Energiya, the so-called "super booster," made its debut on May 15, 1987. It consists of a hydrogen-fueled, central core stage and four liquid-fuel strap-on engines. Payloads of up to 100 metric tons can be carried into space attached to the side of Energiya's core stage. Among the anticipated payloads for the booster during the 1990s are space-station sections, shuttle-type vehicles, and boost stages for interplanetary missions.

Cosmonaut Program. The main cosmonaut training center is at Zvyozdniy Gorodok, or "Starry Town" (sometimes mistranslated as "Star City"). Located about 60 km (40 mi) northeast of Moscow, it includes classrooms, spacecraft simulators, a centrifuge for simulating high-gravity conditions, and an underwater spacewalk-training facility. Military cosmonauts live in apartment complexes with their families at the center. The Soviet flight-control center is located in the town of Kaliningrad, north of Moscow, where many of the leading spacecraft engineering and manufacturing facilities are also located.

Soviet cosmonauts are drawn almost entirely from two distinct groups: military jet pilots, and space engineers. The jet pilots are generally selected at a young age—typically from 22 to 26 years old—and begin a lengthy apprenticeship that involves university training, physical conditioning, rigorous psychological and ideological screening, and actual spaceflight support. Approximately half of the selectees complete the ten-year program. They are then assigned as mission commanders, the only flight assignment available to this group. In the other cosmonaut group, civilian engineers come exclusively from the spacecraft design bureaus and the flight control center, where they have already undergone extensive spacecraft familiarization and personal screening; military flight engineers come from similar aviation backgrounds. The engineers are generally designated as cosmonaut-trainees at about the age of 30 and undergo a five-year program of general preparation before being assigned to a specific mission. Exceptions can be made to these criteria for special purposes. For example, several pilots associated with the Soviet shuttle program have made space missions as flight engineers.

Thus far all Soviet cosmonauts have been ethnic Slavs, and all but a few have been men. Because the Soyuz spacecraft used in manned missions has a maximum mission duration of only six months, however, the need to conduct short, simple replacement flights to space stations such as *Mir* affords the opportunity to place "guest cosmonauts" among the swap crews. Since 1978 more than a dozen non-Soviet guest cosmonauts have been used. The first nine came from Soviet-bloc nations, followed by French, Indian, and Syrian representatives. Plans exist for guest cosmonauts from several other nations, as well.

Space Station and Shuttle. The USSR's manned spaceflight program is centered on development of a permanently manned space station. The current *Mir* ("Peace") station (see SALYUT) orbits the Earth at an altitude of about 360 km (220 mi) and an inclination of 52 degrees.

The Soviet Union conducted a successful unmanned orbital test of its equivalent to the U.S. SPACE SHUTTLE in November 1988. The craft, named *Buran* (and a sister ship, *Ptitchka*), is lifted into space by the Energiya launcher. It closely resembles the U.S. Shuttle but is slightly smaller, and it is designed for use with the *Mir* space station. Although it can carry up to 10 cosmonauts at a time,

John Glenn's 295-minute flight in his Friendship 7 *Mercury capsule on Feb. 20, 1962, made him the first American and third man to orbit the Earth.*

its main use will probably be for carrying cargo up to *Mir.*

Applications Programs. The Soviet Union has sent several unmanned spacecraft toward other planets and into interplanetary space, as discussed in articles on individual programs. The vast majority of Soviet satellites that are launched annually, however, are designed for routine applications purposes. About a dozen "constellations," or groupings, of satellites can be identified in which failed satellites are continually being replaced. A number of other programs exist involving short-term missions. These consist mainly of recoverable satellites carrying military visual reconnaissance equipment or Earth-resources survey cameras, with an occasional biosatellite that carries animal specimens. Such missions are called Kosmos ("Cosmos"; see COSMOS), as are many of the satellite constellations, but they can be distinguished by their low altitudes (from 170 to 420 km/105 to 260 mi) and distinctive orbital inclinations, evidently determined by the use of standardized launch profiles. Thus those with inclinations near 62.8, 67.1, 72.9, and 82.3 degrees come from Plesetsk, whereas those near 64.9 and 70.0 degrees come from Tyuratam. All satellite recoveries take place in Kazakhstan.

Besides these generic programs, a number of specialized programs have been developed in the USSR. Occasional unclassifiable Kosmos missions, for example, conduct unique experimental programs. Scientific satellites in the Prognoz and Astron programs observe the Sun and stars, and a special Earth-resources radar observer named *Kosmos 1870* was launched in mid-1987. The Soviet Union also possesses the world's only operational orbital weapon, the so-called "killer satellite." First tested in the 1960s, the satellite uses a radar-guided, two-orbit attack profile; attempts to perform single-orbit "kills" and to use infrared guidance, however, have been notably unsuccessful. The Soviets announced a unilateral moratorium on further testing of the system in 1982, in an apparent effort to deter the United States from developing an equivalent system. Another Soviet orbital weapon (known in U.S. terminology as the Fractional Orbit Bombardment System, or FOBS) was intended to place a thermonuclear warhead in low orbit for subsequent return to a ground target under extremely brief warning conditions. Tested secretly in the period 1966–70, the system may no longer be operational, but the Soviets have disclosed that 18 FOBS launchers remain in their inventory at Tyuratam.

Finally, in 1985, the Soviets established a space commercialization organization named Glavkosmos, whose purpose is to sell Soviet space services—particularly launch services—to foreign customers. Several Western satellite manufacturers, unable to obtain Western launch services in the period following the *Challenger* disaster, expressed interest in this possibility. The U.S. government, however, applied federal regulations forbidding technology transfer to the USSR, in order to thwart any such agreements by U.S. organizations. This move was based on the fact that satellites to be orbited would have advanced avionics and would technically be "imported" to the USSR while en route to outer space.

Early U.S. space efforts met with an embarrassing series of failures before the first successful launch of Explorer 1 *in 1958. One such failure was this abortive attempt to place a satellite in Earth orbit using a U.S. Navy Vanguard rocket booster. The rocket exploded on its launch pad at Cape Canaveral on Dec. 6, 1957. The Vanguard did not successfully launch a satellite until the following year.*

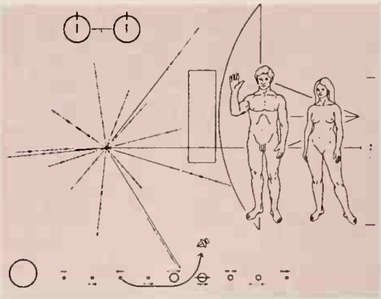
United States

The contrast between the U.S. and the Soviet space programs has been likened to that between the hare and the tortoise in Aesop's fable, and the comparison is apt. Whereas the Soviet program was characterized above as slow and steady, the Americans have approached activity in space in a series of sprints, often subsequently succumbing to retreat and lethargy after periods of great accomplishment. The potential technological reserves of the U.S. space industry remain enormous, but the nation's space program approached the last decade of the 20th century with its capabilities bruised by the *Challenger* disaster of 1986 and its long-range goals still undefined. The SPACE STATION program, for example, is in an advanced stage of development, but plans for its use and international operation remain uncertain. The military STRATEGIC DEFENSE INITIATIVE (SDI) program is also plagued by serious practical and political questions.

The civilian U.S. space program has been managed by the NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA), founded Oct. 1, 1958. As with the Soviet Union, U.S. achievements in interplanetary exploration are described in several individual articles on the specific space probes.

Launch Facilities. The United States operates three main space-launch facilities: CAPE CANAVERAL, Fla.; VANDENBERG AIR FORCE BASE, Calif.; and Wallops Island, Va.

The Cape Canaveral area contains several distinct facilities whose names have changed several times, which has led to frequent confusion. All of the original rocket pads for ATLAS, THOR, and TITAN rockets—and many others no longer in use, such as SATURN I—are located on the long, sandy island named Cape Canaveral. North of this location is Merritt Island, where two large Saturn V pads were built and later converted for Space Shuttle use. This

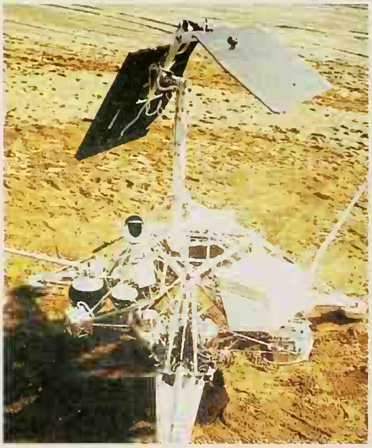


(Above) *This plaque is aboard* Pioneer 10 *and* 11, *both headed out of the solar system. If alien life forms intercept a probe and decipher this plaque, they will learn the location of the Earth in the solar system and of the Sun in our galaxy, as well as the appearance and the size of humans.* (Right) *The two Voyager probes, also outward bound, carry records encoded with images of Earth, human voices, and musical selections ranging from Bach to Chuck Berry.*

new area was called the KENNEDY SPACE CENTER (KSC); it has been the location of all U.S. manned launchings since 1968.

Vandenberg Air Force Base has been used for launching satellites into polar orbit since 1959. The site was developed for this purpose because the local coastline curves eastward, affording a clear path directly southward over the ocean. Although most satellites launched into polar orbit are military, a number are also used for civil applications (such as LANDSAT and various weather satellites) and scientific research as well. A Shuttle launch capability also had been planned at the base, and an old Titan III launching pad had been modified prior to the *Challenger* disaster. The plans were subsequently postponed indefinitely.

The Wallops Island facility is a small base used primarily for launching sounding rockets. It has one SCOUT pad, which occasionally has supported orbital launchings. A second special Scout launching facility, the Italian-operated San Marco platform off the coast of Kenya, has been used to launch several small scientific satellites into equatorial orbit.



This Surveyor craft was one of seven launched from 1966 to 1968 to soft-land on the Moon. Five of the Surveyors succeeded, returning data on the nature of the lunar surface, as part of the U.S. effort to place men on the Moon before the end of the 1960s.

Launch Vehicles. For many years the United States has had a wide range of launch vehicles at its disposal for various space programs. By the late 1970s, however, NASA planning had come to concentrate on the Space Shuttle as the bearer of orbital traffic. Other launch systems remained available, but their future was placed in doubt by pressure from NASA. Following the *Challenger* disaster, however, the old stable of boosters was revitalized and expanded, so that by the 1990s a restored Shuttle and a large number of other launch vehicles would again be available for U.S. space needs. The boosters include the Scout, DELTA, Atlas-CENTAUR, Titan 34, and Titan III. Considerable efforts were also being made to study the possibilities of developing and properly using some new heavy-lift boosters, similar to the Saturn family of vehicles developed in the 1960s. The new boosters could either be derived from existing Shuttle engines or be developed from new technologies that promise considerably lower costs. Applications could include large space-station modules, military payloads, and advanced interplanetary probes.

Astronaut Program. The achievements of the ASTRONAUTS who took part in the first two decades of U.S. manned space exploration are discussed in the articles MERCURY PROGRAM, GEMINI PROGRAM, APOLLO PROGRAM, APOLLO-SOYUZ TEST PROJECT, and SKYLAB. The current professional corps of astronauts consists of about 90 men and women at the JOHNSON SPACE CENTER in Houston, Tex. Approximately half of them are pilots, all of whom are male and almost all of whom are active or retired military officers. The other half are mission specialists. Of these, about half are military flight engineers, and the remaining are civilian scientists and engineers. Recent astronaut selections have been made almost exclusively from the

The shuttle Challenger *is destroyed shortly after being launched on Jan. 28, 1986, killing its crew of seven. The exhaust plumes of the two booster rockets arch away from the ball of fire and smoke caused by the disruption of the main fuel tank.*

The presidential commission that investigated the Challenger *tragedy found fault with NASA's management procedures and quality control. The tape being shown of* Challenger's *liftoff reveals a leaking seal on one booster rocket.*

ranks of federal employees, whether members of the military or employees of NASA or the civil service.

In 1979 the U.S. Air Force initiated a program called Manned Spaceflight Engineers to train military payload specialists for Shuttle flights. Ambitious applications programs were frustrated by lack of interest in the higher levels of the Defense Department, and of two dozen officers in the program only two actually flew on the first 24 Shuttle missions. By the late 1980s the spaceflight cadre had been reduced to about 10.

Space Shuttle and Station. The wide range of missions planned and conducted by the Shuttle program in pre-*Challenger* days, as noted, has been narrowed following the disaster. During earlier flights, more than 30 satellites had been deployed for scientific, commercial, and military purposes. This revenue-generating activity was widely billed as a justification for the program, but reimbursements never matched operational expenses; most post-*Challenger* commercial launch contracts have been abrogated unilaterally by NASA. Similarly, few scientific research missions remain on planned Shuttle schedules. On the other hand, the capability for repairing and retrieving damaged spacecraft that was demonstrated by the Shuttle on earlier flights will remain available in the future. In addition, past Shuttle missions provided small amounts of extra cargo space or extra payload-lift capacity that usually was filled with small add-on packages, either from NASA, industry, or university laboratories, or from programs called the Getaway Special (GAS) and Student Experiments. These flexible and low-cost spaceflight opportunities will continue.

Since 1984, when President Ronald Reagan directed NASA to build a permanently manned space station as its next major project, the program has evolved into a highly sophisticated structure designed to support six to eight astronauts in orbit. Several scientific modules and large amounts of electrical power are planned for the station. Plans also call for significant participation by European, Canadian, and Japanese space agencies, but concern about ill-defined Defense Department interests in the station remains an issue of international contention. The first sections of the structure are scheduled to be launched by about 1995, and up to ten Space Shuttle missions may be needed to fully assemble the station. The use of a large unmanned rocket is being considered as part of the program, and concerns over crew rescue and evacuation may also lead to the development of a simple bail-out module for the station.

Applications Programs. The United States has conducted many applications programs and scientific projects in Earth orbit, which are discussed in numerous individual articles. Of ongoing programs that have become firmly integrated into everyday life, the two leading types involve COMMUNICATIONS SATELLITES and synchronous meteorological satellites. Dozens of the former type of satellite exist, built and operated by a number of different corporations. Of the latter—beyond the two past satellites of that specific name—the most important is the Geostationary Operational Environmental Satellite (see GOES) operated by the National Oceanographic and Atmospheric Administration (NOAA). Low-orbit weather satellites are also administered by NOAA and are launched into polar orbit under code names such as *NOAA 9* and *NOAA 10*.

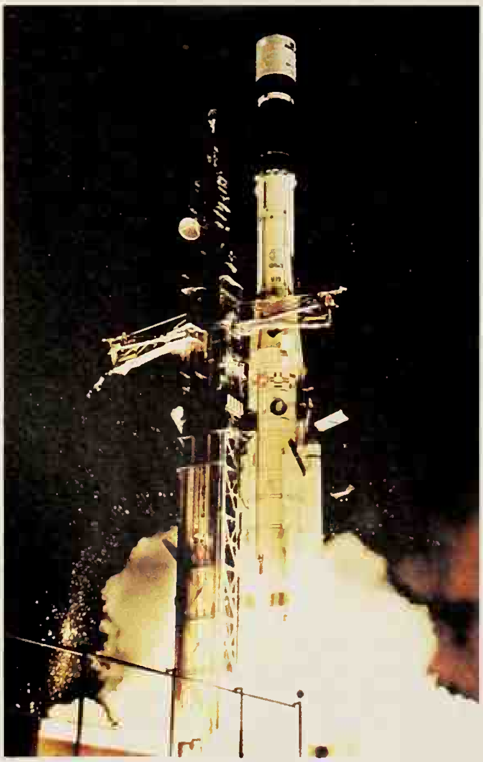
Technical difficulties surrounded NASA's attempt to develop an advanced space-to-space communications relay system called the Tracking and Data Relay Satellite System, or TDRSS (see TRACKING STATION). A network of two operating satellites and one spare, in geosynchronous orbit, was to have provided nearly full-time radio links with Space Shuttle missions, along with high-volume data relay from applications satellites such as Landsat. The first payload was launched by a Shuttle in April 1983 but, following a major upper-stage booster problem, was barely able to limp into proper orbit. Subsequent launchings were delayed, and the second satellite was destroyed by the *Challenger* disaster. The system was finally completed by two Shuttle-launched TDRS satellites in 1988 and 1989.

Another program seriously affected by the *Challenger* incident was called the Long-Duration Exposure Facility, or LDEF. Original plans called for an early retrieval of the LDEF satellite deployed in 1984 by Shuttle, but this recovery was repeatedly postponed. On the other hand, many scientific satellites continued to operate during the post-*Challenger* lull in launchings, and two major probes—*Magellan* to Venus and GALILEO to Jupiter—were sent on their way in 1989 after Shuttle flights resumed the preceding year. The most spectacular science mission launched from the Shuttle was the Hubble SPACE TELESCOPE, but a number of other probes to the outer solar system are also waiting their turn on a Shuttle in the mid-1990s. They include *CRAF* (Comet Rendezvous Asteroid Flyby) and *Cassini*, the latter to journey to Saturn and Titan.

With respect to military programs, by the late 1980s the Defense Department space budget well exceeded that of NASA. Expenditures were primarily for applications such as communications, tactical meteorology, navigation, missile warning, and reconnaissance. Military satellites are controlled from Onizuka Air Force Station in Sunnyvale, Calif., and from Falcon Air Force Station in Colorado Springs, Colo. Reconnaissance satellites, developed under the designation Keyhole (KH), perform an invaluable monitoring role by allowing detection of weapons buildups and providing verification for arms-control treaties. Satellites in the older KH 9, or "Big Bird," series sent film back in small capsules, but the KH 11 satellites that have been operating since 1976 can transmit observations directly to ground stations. Each of them can operate for up to two years in orbit.

Other military activities in space include the antisatellite (ASAT) missile being developed by the air force for launch from high-flying aircraft against targets in low orbits. Testing on ASAT was suspended, however, in response to a Soviet moratorium on its own so-called killer satellite. Research continues on the highly controversial SDI system, often referred to as "Star Wars." The system, if developed, would require many facilities to be prepositioned in space to make possible extremely rapid detection of and reaction to attack. The range, coordination, and effectiveness of such facilities are issues currently being examined.

The European Space Agency (ESA) is actively pursuing several space exploration projects, making frequent use (left) *of its heavy-duty Ariane series of launch vehicles.* (Right, top) *The Hotol spaceplane of Great Britain, still in the planning stage, would be an orbital craft that takes off and lands like a plane.* (Right, bottom) *The Hermes spaceplane, a modified version of the U.S. Space Shuttle, was accepted for development by ESA in 1987. It will be launched in the 1990s atop the powerful* Ariane 5 *rockets also under development.*



Europe

Many nations of Western Europe are engaged to some degree in space activities; primarily in the form of satellite manufacture and the development of research projects to be pursued in orbit. The major nations also have their own governmental space agencies, and 14 European countries have joined to form the EUROPEAN SPACE AGENCY (ESA). The achievements of this organization are highlighted by the development of the ARIANE family of rockets, the SPACELAB module, and the Giotto probe to HALLEY'S COMET.

The Ariane rocket was developed to provide the European nations with independent access to space, and it is also promoted on a commercial basis for the launching of non-European payloads. The rockets consist of French-built first and second stages and a German-built, hydrogen-fueled third stage. Although a series of failures followed the early successful launching of Ariane, the orbiting of an Australian and a European satellite by Ariane V19 in 1987, and subsequent successes, seemed to indicate that the program was back on course. Expanded launch facilities are planned at the Ariane launch site, the Guiana Space Center at Kourou.

The ESA has an official astronaut program, which was originally designed to train candidates for Spacelab missions aboard the U.S. Space Shuttle. Three candidates were selected in 1980, two of whom flew actual missions before the *Challenger* disaster drastically curtailed the program; in addition, two West German physicists also flew aboard the Spacelab as payload specialists. In 1987 the West Germans selected five more astronauts—two women and three men—to train for flights aboard the Shuttle and, possibly, remaining Spacelab missions. The trainees have scientific-research backgrounds but lack test-pilot experience. In France a group of eight "spationautes" was selected to train for participation in possible Shuttle programs as well. Prior to that, a French pilot took part in the Soviet "guest cosmonaut" program aboard *Salyut 7* in 1983, and his understudy took part in a seven-day Shuttle mission in 1985. ESA is also defining astronaut requirements for its proposed Hermes manned spaceplane and Columbus space-station programs; if these programs go forward, a corps of up to 20 professional astronauts may eventually be required.

ESA has also developed a number of advanced applications satellites. The Meteosat program, which began in 1977, involves weather monitoring from geosynchronous orbit. The European Communications Satellite (ECS) and its maritime version, MARECS, are ongoing programs to develop and use highly advanced communications technology. These applications satellites are administered by international groups known as Eutelsat (for ECS) and Inmarsat (the International Maritime Satellite Organization).

Japan

Japan's National Space Development Agency (NASDA) was formed in 1968 as the federal agency for developing space technology, in part because of limitations placed on the older Institute of Space and Aeronautical Sciences (ISAS) operated by the University of Tokyo. The latter has since been reorganized as an autonomous agency under the education ministry. Japan first achieved independent launch capability in 1970; since then it has launched many research, observation, and communications satellites. In 1985 it also successfully launched two probes on trajectories that took one of them past Halley's comet in 1986. NASDA launches applications satellites from two pads at Tanegashima at the southeastern tip of Kyushu, while ISAS launches scientific satellites from its own pads at Kagoshima.

Early Japanese boosters, such as the N I and N II, used licensed adaptations of the U.S. Thor rocket, but a more powerful and entirely Japanese-developed booster named H 1 was successfully flown for the first time in 1986. The upper stage of H 1 uses liquid hydrogen and can place payloads of about 1,500 kg (3,300 lb) in low Earth orbits.

In 1985, NASDA selected three astronauts for a planned Spacelab mission. The Japanese are also planning a major role in the U.S. space station through development of a laboratory module. Ambitious programs in the farther future include solar probes and, possibly, a shuttle for servicing a manned space "factory" in the 21st century, keeping the nation in the forefront of manufacturing techniques.

China

China, which in 1970 became the fifth nation to launch its own satellite, followed the pattern of the Soviet Union and the United States in basing its early boosters on military missiles. Its capabilities in space technology have grown rapidly since then. Current boosters are designated as various models of the so-called Chang Zheng ("Long March") design. The first operational space booster, the three-stage CZ 1, had a liftoff thrust of 140 metric tons and could carry an orbital payload of about 300 kg (660 lb). The CZ 2 flown in 1974 had a greater thrust and could lift up to 3 metric tons into orbit. The high quality of Chinese space technology was demonstrated in 1984 by the development of a cryogenic hydrogen-fueled third stage for the CZ 2 to produce the CZ 3, since a rocket stage of this type had previously been achieved only by the United States and West Germany. By the late 1980s China entered into commercial agreement to launch Western communications satellites on its advanced booster.

The original Chinese space center is located near the town of Shuangchengzi in Gansu province of western China. This site is now referred to as Jiuquan in official Chinese records. A more southerly site opened in 1984 for launching larger boosters toward geosynchronous orbits is referred to officially as Xichang. Early satellite launchings involved various test payloads and scientific instruments, but since 1975 the Chinese have been able to fly recoverable payloads carrying camera systems for military reconnaissance and Earth-resources surveys. The Chinese in the future intend to launch more-advanced communications satellites and their own meteorological satellites.

China is forging ahead with ambitious space programs for the 1990s. (Above) *The facilities at the Xichang launch site include this large range control center, operated by the People's Liberation Army. Basic launch and tracking information is displayed on boards at the front of the room.* (Right) *A* Chang Zheng *("Long March") 3 rocket is prepared for launch from its pad, about 3 km (2 mi) away.*

Discussions of plans for manned space missions have been reported for several years, but any precise plans and schedules are unknown. In the meantime, China is entering into commercial agreements to launch various Western communications satellites with its CZ 3 booster.

India

India has an active space program that concentrates on the development of aerospace technology and on direct economic applications of such technology. It also makes use of communications satellites for nationwide educational systems. The Department of Space, established in the early 1970s, has the Indian Space Research Organization (ISRO) as a major unit. Various development facilities exist around the subcontinent, with launch sites at Sriharikota, north of Madras on the eastern coast, and at Trivandrum, at the far southern end of India.

Prior to achieving its own launch capability in 1980, India had a number of satellites orbited by the Soviet Union and the United States, and in 1981 a test communications satellite named Apple was successfully launched by an Ariane rocket. India's first rocket, the Satellite Launch Vehicle (SLV), has been used for sending India's small Rohini satellites into orbit, and the nation is developing an augmented version with four times the payload. A still larger version of the SLV is also being developed for launching payloads into polar orbit. A new launch site is required for the latter program, however, and a location west of Calcutta has been proposed. In manned programs, an Indian pilot took part in a Soyuz visit to the *Salyut 7* space station in 1984. Two other Indian engineers were selected in 1985 to train as payload specialists on a Space Shuttle mission, but the mission was subsequently canceled.

Canada

Canada's space exploration activities concentrate on science and engineering of direct use to the nation. Canada has conducted pioneering work on domestic communications satellites, ionospheric physics satellites, and robotics and control systems. For example, Canada developed the robot arm used on the Space Shuttle, and it is planning an advanced version of the arm for the U.S. space station, *Freedom*. In 1989, Canada formed a central organization, the Canadian Space Agency, to coordinate its activities in space exploration.

In 1983 six Canadian astronaut trainees were selected to take part in Space Shuttle missions. One of the men flew aboard a mission in 1984, but the other missions were delayed or canceled by the *Challenger* disaster.

Other Nations

Several other nations have been involved in space activities, either alone or in partnership with major spacefaring nations. Many more nations share the communications-satellite, weather-satellite, and Earth-resources-monitoring data from the space programs of the United States, the Soviet Union, and the ESA. In manned space activities, nations that have taken part in the Soviet's guest cosmonaut program include Poland, East Germany, Hungary, Vietnam, Cuba, Mongolia, Romania, Syria, Bulgaria, and Afghanistan.

In South and Central America, Argentina makes use of small sounding rockets and has proposed a domestic communications satellite and a small scientific satellite for launch by NASA in the 1990s. Brazil also builds sounding rockets and is a major user of communications satellites, as is Mexico.

In Europe, Sweden is another frequent user of sounding rockets, and it develops its own satellites for polar ionospheric research. Czechoslovakia conducts significant work in space instrumentation and has produced piggyback satellites for launching on Soviet vehicles. The first person in space who was from neither the United States nor the Soviet Union was the Czech astronaut Vladimir Remek, a guest aboard a 1978 Soyuz flight.

Elsewhere in the world, Israel initiated its own space program in 1988 and intends to develop reconnaissance satellites for use by its defense forces. Also in the Middle East, Saudi Arabia is a leading member of the ARABSAT communications satellite organization. Indonesia is another major user of communications satellites, and its own satellites have been orbited by various space organizations.

Finally, Australia is the site of tracking facilities used by these organizations. It also once launched (1967) its own satellite, WRESAT, aboard a modified Redstone rocket from the Woomera test range, and it remains another major user of communications satellites.

Space Shuttle The U.S. Space Shuttle is a reusable spacecraft designed to be launched into orbit by rockets and then to return to the Earth's surface by gliding down and landing on a runway. The Shuttle was selected in the early 1970s as the principal space launcher and carrier vehicle to be developed by the National Aeronautics and Space Administration (NASA). It was planned as a replacement for the expensive, expendable booster rockets used since the late 1950s for launching major commercial and governmental satellites. Together with launch facilities, mission control and supporting centers, and a tracking and data-relay satellite system, it would complete NASA's new Space Transportation System (STS).

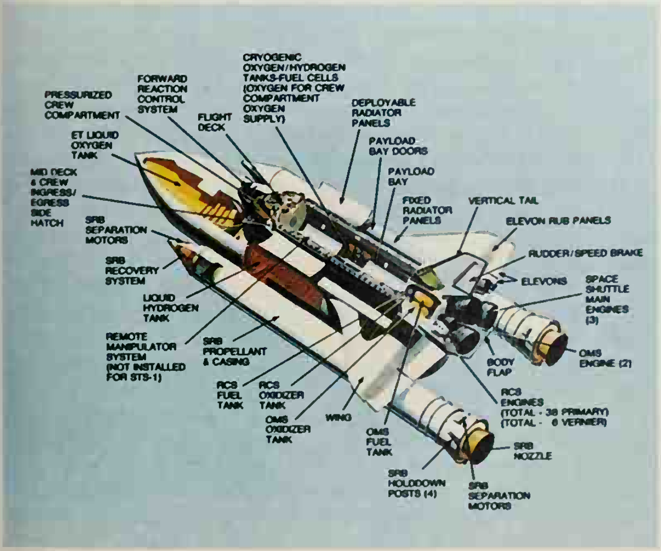
After various delays the program got under way in the early 1980s. Despite a number of problems the craft demonstrated its versatility in a series of missions until, in January 1986, a fatal Shuttle disaster during launch forced a long delay until the program was resumed late in 1988. The disaster and its results are described at the end of this article; the following account of the Shuttle's characteristics describes the original vehicle. Modifications made in the aftermath of the disaster did not affect the basic design of the craft nor its overall dimensions.

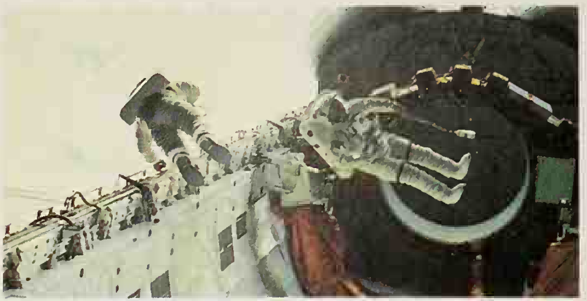
Components. The three main components of the Space Shuttle are the orbiter, the external tank, and the solid rocket boosters. The Shuttle weighs 2.0 million kg (4.5 million lb) at launch and stands 56.1 m (184.2 ft) tall. It can carry up to 29,500 kg (65,000 lb) of cargo on one mission.

The orbiter is 23.79 m (78.06 ft) across the wing tips and 37.2 m (122.2 ft) long. During launch it is a rocket stage, in orbit it is a spaceship, and on reentry and landing it is a hypersonic glider. A two-deck crew compartment and an attitude thruster module are in the nose, the midbody is the cargo hold, or payload bay (4.6 m/15 ft wide and 18.3 m/60 ft long), and the tail holds the three main engines plus maneuvering engine pods. Each engine, burning hydrogen and oxygen, produces up to 213,000 kg (470,000 lb) of thrust.

The external tank—actually an oxygen tank and a hydrogen tank joined by a load-bearing intertank—is the structural backbone of the Shuttle. Measuring 8.38 m (27.56 ft) wide and 47 m (154.2 ft) tall, it carries

(Left) *The diagram of the Space Shuttle shows the payload bay doors open to reveal the craft's interior. The bay is designed to hold satellites, scientific experiments, or cargoes as large as Spacelab.* (Right) *The launch of the orbiter* Discovery *on Sept. 29, 1988, marked the start of the 26th Shuttle mission and the successful resumption of the program following the* Challenger *disaster in 1986.*





The sixth Space Shuttle mission took place in April 1983. During this first flight of the orbiter Challenger, *mission specialists Donald Peterson and Story Musgrave* (top) *achieved a period of extravehicular activity (EVA). The men are seen in the cargo hold area, opened to the environment of outer space. The mission ended safely* (bottom) *five days later, at Edwards Air Force Base.*

709,750 kg (1,565,000 lb) of liquefied propellants for the main engines.

Two solid rocket boosters, each 3.7 m (12.1 ft) wide and 45.5 m (149.2 ft) tall, are attached. Each produces an average thrust of 1.20 million kg (2.65 million lb).

Typical Mission. At 3.8 sec before liftoff the Shuttle's three main engines are ignited. At T + 2.88 sec (2.88 sec after liftoff) the twin boosters are ignited and the hold-down bolts released. As soon as it clears the fixed gantry, the Shuttle pitches to fly with the orbiter upside down because the craft's design puts the thrust vector off center.

At T + 2 min 12 sec the boosters burn out and are jettisoned to parachute into the ocean for recovery. Meanwhile the Shuttle continues on under the power of the main engines. Just short of orbital velocity, the engines are shut down (T + 8 min 32 sec) and the tank is jettisoned (T + 8 min 50 sec). The orbiter's own orbit-adjust engines act as the third stage that puts the craft into orbit.

The Shuttle has carried a variety of cargoes (see SPACE EXPLORATION), including SPACELAB, SPACE TELESCOPE, and commercial and military satellites. After completing a mission, the Shuttle closes its cargo doors and the maneuvering engines are fired as retrorockets. Braked by the atmosphere, the Shuttle rapidly slows from Mach 25 (25 times the speed of sound) at 121,920 m (400,000 ft) to subsonic speeds before it lands.

Crew. Unlike earlier manned space programs, the Shuttle allows greater specialization of crew members and flights by persons from outside the astronaut corps. There are two principal types of Shuttle astronauts, pilots and mission specialists. Pilots—typically, military-trained jet pilots—fly the Shuttle with a mission commander (a senior astronaut) in the left seat and a pilot in the right seat of the cockpit. The mission specialist is in charge of the cargo the Shuttle carries. Befitting the Shuttle's wide range of missions, mission specialists come from such widely ranging disciplines as medicine, astrophysics, materials engineering, and electronics.

History. The Shuttle program was formally authorized on Jan. 5, 1972. In 1977–78 the first Shuttle, *Enterprise*, made five landing tests at Edwards Air Force Base, Calif., after being carried aloft by a Boeing 747. Testing was also under way on the engines and boosters; the final flight-readiness firing took place on Feb. 20, 1981, when the three main engines of *Columbia*, the first flight orbiter, were fired together in a pad test at KENNEDY SPACE CENTER (KSC).

First launch, with commander John Young and pilot Robert Crippen aboard, was made on Apr. 12, 1981. The Shuttle landed successfully at Edwards AFB on April 14. The second test flight (Nov. 12–14, 1981), with commander Joe H. Engle and pilot Richard H. Truly, was cut short from 5 to 2 days because of a fuel-cell failure. The third flight (Mar. 22–30, 1982), commanded by Jack R. Lousma and piloted by C. Gordon Fullerton, was extended by one day and became the first to land at White Sands, N.Mex. Commander Thomas Mattingly and pilot Henry W. Hartsfield were aboard the fourth flight (June 27–July 4, 1982). The fifth flight (Nov. 11–16, 1982), commanded by Vance D. Brand, and including an expanded crew of three, was the first operational flight. Two commercial communications satellites were deployed into Earth orbit.

Flight six, the first to use the orbiter *Challenger*, was flown Apr. 4–9, 1983, by commander Paul Weitz, who was joined by a crew of three. Mission specialists Donald Peterson and Story Musgrave achieved EVA. The crew deployed *TDRS 1*, a communications satellite that strayed but was nudged into correct orbit by ground control. On flight seven, June 18–24, 1983, *Challenger*'s commander Robert Crippen was joined by a crew of four, which included Sally K. RIDE, the first U.S. woman astronaut. The crew successfully deployed and retrieved West Germany's *SPAS-01* test satellite, using the Shuttle's robot arm; they also deployed Canada's *Anik C* and Indonesia's *Palapa B* communications satellites. Flight eight, Aug. 30–Sept. 5, 1983, began with the first night launch of *Challenger*. Commander Richard Truly was joined by a crew of four, including Guion S. Bluford, the first black U.S. astronaut. This crew launched India's *Insat-1B* satellite. Flight nine, flown Nov. 28–Dec. 8, 1983, carried the first Spacelab aboard *Columbia*. Commander John Young was joined by a crew of five, including Owen Garriott, a veteran astronaut, who had spent time aboard *Skylab* in 1973. This crew conducted inner-ear studies and biological and materials-science tests.

Failures in STS 9 auxiliary power units delayed the tenth Shuttle flight until Feb. 3–11, 1984. Aboard the *Challenger* were commander Vance D. Brand and a crew of four. They achieved the successful testing of the manned maneuvering unit, a jet-propelled system that enabled Bruce McCandless and Robert Stewart to move freely in space, and the first Shuttle landing at Cape Canaveral. Two satellites launched by the crew, however—Western Union's *Westar* and Indonesia's *Palapa B-2*—did not enter proper orbit because their own rockets failed. The 11th Shuttle mission was flown in *Challenger* on Apr. 7–13, 1984, by commander Robert L. Crippen and a crew of four. The crew's most difficult assignment, successfully carried out, was to restore to service the malfunctioning *Solar Maximum Mission* research satellite.

The 12th mission was dramatically aborted 2.6 seconds after engine startup on June 26, 1984, when a fuel valve on one engine of the new Shuttle, *Discovery*, failed to open. The flight finally took place on Aug. 30–Sept. 5, 1984, with commander Henry W. Hartsfield, Jr., and a crew of five. Charles Walker became the first person from private industry (McDonnell Douglas Corporation) to fly in the Shuttle. The crew launched the *SBS-4*, *Leasat-2*, and *Telstar-3* communications satellites. The 13th mission took place on Oct. 5–13, 1984, in *Challenger*, with commander Robert Crippen and a crew of six. Sally Ride overcame mechanical problems in the launching of the *Earth Radiation Budget Satellite*. The 14th Shuttle mission took place on Nov. 8–15, 1984, in *Discovery*, with commander Frederick H. Hauck and a crew of four. The crew retrieved the two satellites that had failed after their launch on the 10th Shuttle mission, and brought them safely back to Earth. The crew also launched two new communications satellites.

The 15th Shuttle flight took place on Jan. 24–27, 1985, in *Discovery*, with commander Thomas K. Mattingly and a crew of four. On this, the first flight to be reserved by the U.S. Defense Department—and therefore veiled in secrecy—an important satellite-boosting rocket was successfully tested. The 16th Shuttle flight took place on Apr. 12–19, 1985, in *Discovery*, with commander Karol J. Bobko and a crew of six. Included in this crew was U.S. senator Jake Garn, who took part in medical experiments during the flight. A Navy Leasat communications satellite was deployed but failed to activate itself in order to move to a proper orbit.

The 17th Shuttle flight took place on Apr. 29–May 6, 1985, in *Challenger* and included commander Robert F. Overmyer, a crew of six, and the second Spacelab. Aboard were 2 squirrel monkeys and 24 white rats that were part of experiments designed to investigate motion sickness. The 18th Shuttle flight took place on June 17–24, 1985, in *Discovery*, with commander Daniel C. Brandenstein and a crew of six. During this mission three communications satellites were deployed, including the Arabian *Arabsat* and the Mexican *Morelos A*. A Spartan X-ray, deep-space telescope was deployed and retrieved. A reflector was also placed in a Shuttle window to test the ability of ground-based lasers to focus on space targets (see STRATEGIC DEFENSE INITIATIVE).

After a series of six successful flights over the next six months, disaster struck. The 25th flight, and the 10th flight of *Challenger*, ended less than two minutes after liftoff on Jan. 28, 1986, when a fireball interrupted the craft's ascent track in full view of the crowd below. This disaster killed the entire crew: commander Francis Scobee; pilot Michael Smith; mission specialists Judith Resnik, Ellison Onizuka, and Ronald McNair; and payload specialists Gregory Jarvis and Christa MCAULIFFE, a high school teacher chosen for the flight in a nationwide competition.

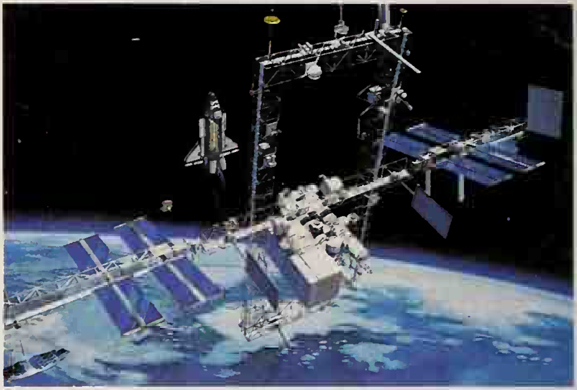
The crew of the 25th Space Shuttle mission, launched Jan. 28, 1986, aboard Challenger, *represented the first in-flight casualties of the U.S. space program. Its members were* (front row, from left) *Michael Smith, Francis Scobee, Ronald McNair;* (back row, from left) *Ellison Onizuka, Christa McAuliffe, Gregory Jarvis, and Judith Resnik.*

NASA suspended Shuttle operations pending the report of a presidential investigatory commission headed by former secretary of state William P. Rogers. Former astronaut Neil Armstrong was vice-chairman, and other members included astronaut Sally Ride and Nobelist Richard Feynman. In its June 1986 report the commission placed immediate blame on a faulty O-ring seal between segments on one of the solid-fuel booster rockets. In part due to cold weather and buffeting by winds during launch, the seal allowed flames to attack the main liquid-fuel tank and a linking strut. The booster's upper end then swung into the main tank, and the whole assembly burned almost explosively. (The Shuttle broke into segments that fell into the ocean, and some were later recovered.) The commission criticized NASA's management procedures, overambitious schedules, and inadequate quality-control systems.

NASA underwent management changes and staff reductions as it revised the Shuttle. President Ronald Reagan authorized a *Challenger* replacement but also ordered the agency to cease launching commercial satellites, thus ending hopes for its eventual financial independence. The government instead planned to have the Shuttle employed mainly for military missions and space-station assembly. In 1989, NASA announced it would not let civilians fly on the Shuttle.

Flights restarted with the successful 26th Shuttle mission of Sept. 29–Oct. 3, 1988, when commander Frederick Hauck and a crew of four flew *Discovery* and launched a TDRS satellite (see TRACKING STATION). The 27th mission, flown by Robert Gibson and a crew of four aboard *Atlantis*, Dec. 2–6, launched a military satellite. The *Discovery* mission of Mar. 13–18, 1989, flown by Michael Coats and a crew of four, launched a TDRS satellite. The May 4–8 flight of *Atlantis*, commanded by David Walker with a crew of four, set the probe *Magellan* toward Venus. Brewster Shaw, Jr., and a crew of four on *Columbia*, Aug. 8-13, orbited another military satellite. On Oct. 18–23, Donald Williams and a crew of four launched the GALILEO Jupiter probe from *Atlantis*. The *Discovery* mission of Nov. 22–27, flown by Frederick Gregory and a crew of four, launched a spy satellite. On Jan 9–20, 1990, Daniel Brandenstein and a crew of four flew *Columbia* to launch Syncom IV and retrieve the Long Duration Exposure Facility. Another spy satellite mission followed on Feb. 28–Mar. 4, when John Creighton and a crew of four flew *Atlantis*. The Hubble SPACE TELESCOPE was finally placed in orbit by *Discovery's* crew of four, commanded by Loren Shriver, during their Apr. 24–29 flight. Because of hydrogen-leak problems the next flight did not take place until Oct. 6–10, when Richard Richards and a crew of four successfully launched *Ulysses*, a solar probe, from *Discovery*. On Nov. 11–15, Richard Corey and a crew of four aboard *Atlantis* launched a spy satellite. During the Dec. 2–10 *Columbia* flight, Vance Brand and a crew of six attempted a complex astronomy program but ran into severe mechanical problems.

On the *Atlantis* mission of Apr. 5–11, 1991, Steven Nagel and a crew of four launched the Gamma Ray Orbiter, the heaviest satellite yet orbited by the Shuttle program. The Apr. 28–May 6 flight of *Discovery*, with Michael Coats and a crew of six, tested elements of the SDI program. *Columbia* returned to space on June 5–14, with Bryan O'Connor, a crew of six, and a *Spacelab* module for medical tests. John Blaha and a crew of four flew *Atlantis*, Aug. 2–11, launching a final TDRS satellite. The Sept. 12–18 *Discovery* mission, with John Dreighton and a crew of four, orbited the Upper Atmosphere Research Satellite. Frederick Gregory and his crew of five aboard *Atlantis*, Nov. 25–Dec. 2, orbited a satellite for detecting missile launches. On *Discovery*, Jan. 22–30, 1992, Ronald Grabe and a crew of six studied cosmic radiation effects. On *Atlantis*, Mar. 15–Apr. 2, Charles Bolden and a crew of six observed atmospheric processes. *Endeavour* made its first flight on May 7–16 with Daniel Brandenstein and a crew of six, who achieved a hands-on rescue of INTELSAT *6*. The *Columbia* science mission of June 25–July 9 was conducted by Richard Richards and a crew of six. On July 31–Aug. 8, Loren Shriver and his crew of six on *Atlantis* launched a European science satellite. On Sept. 12–20, Robert Gibson and a crew of seven aboard *Endeavour* conducted an American-Japanese biology-research mission using Spacelab-J. LAGEOS-2 was launched from *Columbia*, Oct. 22–Nov. 1, by James Wetherbee and a crew of five.



The U.S. space station once planned for deployment in the 1990s might have looked like this when the station had reached its fullest development stage. A Shuttle is seen orbiting near the station, with cargo bay open.

space station A space station may be defined as a permanently inhabitable platform for humans and instruments in outer space. Space stations may serve as bases for research and manufacture and as locales for large colonies. Physicist Hermann OBERTH was the first to explore seriously the problems of building such a station. In 1929, *The Problems of Space Flight* by Hermann Noordung (pseudonym of an Austrian army captain) described a wheel-shaped station that would rotate to provide artificial gravity. This was popularized by others such as Werner von BRAUN. Noted designs also include those of U.S. physicist Gerard K. O'Neill, whose proposed structures would house thousands of persons in an Earthlike environment.

The first true space station, SALYUT *1*, was launched by the Soviet Union on Apr. 19, 1971. It was followed by other Salyuts and the more versatile *Mir*. The only true U.S. space station yet launched has been SKYLAB, which housed three crews in 1973–74. When studies suggested that U.S. plans for a larger station were impractical without a reusable transportation system, priority was switched to the SPACE SHUTTLE program.

In 1984, President Ronald Reagan announced a project to establish a permanent station, *Freedom*, within 10 years, and the European Space Agency (ESA), Japan, and Canada agreed to take part. Since then, however, the program has been subjected to budget cuts and to rethinking of its basic purpose. In 1990 a study indicated that the planned station would require thousands of hours of maintenance work every year, so in 1991 its size was reduced to facilities for a crew of four, and the timetable for occupancy was pushed back to the year 2000 at the earliest. The other planned partners expressed some doubts as to their continued involvement in the *Freedom* project.

See also: SPACE PROGRAMS, NATIONAL.

space suit see LIFE-SUPPORT SYSTEMS

Space Telescope The Space Telescope program of the U.S. National Aeronautics and Space Administration was designed to orbit a large telescope that would permit scientists to peer up to 10 times more sharply into the universe than they can with Earthbound instruments. The program was originally approved by Congress in 1977, and the telescope was named the Hubble Space Telescope (HST) in 1984 in honor of the American astronomer Edwin HUBBLE. After years of delays and large cost overruns, the HST was finally launched from the Space Shuttle *Discovery* on Apr. 25, 1990, into an orbit 613 km (381 mi) above the Earth's surface. A team of 300 workers commands HST at Goddard Space Flight Center, and the telescope's scientific activities are coordinated by the Space Telescope Science Institute (STScI) in Baltimore, Md.

The HST is housed in an aluminum cylinder 4.3 m (14 ft) wide and 13 m (43 ft) long, while two panels covered with solar cells supply electrical power to the satellite. The telescope's main mirror is 2.4 m (94.5 in) in diameter. The secondary mirror, positioned at the prime focus of the primary, reflects light to five instruments located at the principal focus. Each instrument is housed in a separate but identical module, permitting later substitution of other instruments. A faint-object camera, provided by the European Space Agency (ESA), has a small field of view and examines the ultraviolet, visible, and near-infrared regions of the spectrum. HST also carries a wide-field camera with a field about 40 times greater but with lesser powers of resolution. High-resolution and faint-object spectrographs aboard the craft have a wide range of spectral resolutions, while a photometer on HST measures the brightness of stars and the galactic background. A system of bright-star sensors and precision gyroscopes can point the telescope to a high degree of accuracy and allow it to remain on a target for extended periods of time.

Shortly after HST was deployed, the discovery was made that the primary mirror was flawed and could not focus properly. Investigators finally tracked the cause of the error to a device used in measuring and testing the mirror. Other systems on HST were functioning well, however, and NASA planned to compensate for the flaw by a Shuttle mission, perhaps in 1993, that would install a corrective camera.

The Hubble Space Telescope is maneuvered into orbit high above the Earth by the manipulator arm of the Space Shuttle Discovery. *Its antennas and solar-array panels have not yet been deployed.*

space-time see COSMOLOGY (astronomy); RELATIVITY

Spacelab Spacelab is a combination workshop and laboratory built by ten European nations for a variety of missions in Earth orbit aboard the U.S. SPACE SHUTTLE. Spacelab began officially in March 1973 when the European Space Research Organization (now incorporated into the EUROPEAN SPACE AGENCY) asked interested nations to sign an arrangement for a Space Laboratory Program; the signers now include Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Switzerland, the United Kingdom, and one nonmember of the ESA, Austria. They were to design, fabricate, pay for, test, and deliver a Spacelab unit and were to have the capability to produce additional ones. NASA would be responsible for Spacelab operations after delivery. Each Spacelab was to be reusable for as many as 50 missions in space.

Spacelab 1, flown aboard the *Columbia* on the ninth Shuttle mission on Nov. 28–Dec. 8, 1983, performed experiments on materials processing, Earth resources, and life sciences. The second mission, called *Spacelab 3* because of its original flight-list position, was flown Apr. 29–May 6, 1985, aboard the *Challenger*—as were the next two missions. Its program was conducted successfully despite problems resulting from free-floating materials that escaped animal cages on the craft. *Spacelab 2*, flown July 29–Aug. 6, 1985, was also successful after an earlier launch abort and an engine shutdown when launch took place. For the fourth mission, *Spacelab D1*, on Oct. 29–Nov. 6, 1985, Spacelab control was turned over to the German Space Operations Center, the first time such responsibilities were shifted outside of the United States.

When the destruction of the *Challenger* during launch on Jan. 28, 1986, caused a two-year delay in the Shuttle program, NASA canceled about 15 Spacelab missions planned for the late 1980s. Only three missions remained on the new schedule for that time period—a great disappointment to the European space community.

SPAD The SPAD XIII was one of the most successful of the French World War I single-seat fighters. It first flew in April 1917. A biplane, the SPAD had an 8.1-m (26.5-ft) wingspan and was designed by a team under the direction of Louis Béchereau. In its final form the SPAD XIII was powered by a supercharged 220 hp Hispano-Suiza 8 Be engine and armed with two fuselage-mounted 7.65-mm (0.3-in) Vickers machine guns. Apart from its extensive service with 81 French fighter squadrons, the SPAD XIII was also used by British, Italian, Belgian, and American units.

spadefish Spadefishes are several species of deep-bodied, laterally compressed fishes in the family Ephippidae. Schools are usually found in the tropical and temperate marine waters of the Americas and West Africa. The American Atlantic spadefish, *Chaetodipterus faber,* a commercially important species in the tropics, ranges from Cape Cod to Brazil. It may reach a length of 3 m (10 ft) and a weight of 9 kg (20 lb).

Spahn, Warren Warren Edward Spahn, b. Buffalo, N.Y., Apr. 23, 1921, an American professional baseball player, won 363 games during his 21-year pitching career, which began in 1942 when he joined the Boston Braves. After the Braves moved to Milwaukee, Wis., in 1953, Spahn, a left-hander, enjoyed his best seasons. During his career he won 20 or more games in a season 13 times, pitched 63 shutouts, and led the National League in complete games 9 times. In 1963, at the relatively advanced age of 42, Spahn won 23 games. He retired in 1965, and in 1973 he was voted into the Baseball Hall of Fame.

Spain Spain, Europe's third largest nation, occupies most of the Iberian Peninsula. Mainland Spain contains about 98% of the national territory; the country also includes the Balearic Islands, in the Mediterranean Sea; the Canary Islands, 1,046 km (650 mi) southwest of the mainland; the cities of Melilla and Ceuta, Spanish enclaves on the northern coast of Morocco; and small offshore islands. Mainland Spain shares borders with Portugal on the west, France and Andorra on the north, and Gibraltar, held by Great Britain since 1704, on the south. Spain was united under the "Catholic kings" Ferdinand II of Aragon and Isabella I of Castile in the 15th century and reached a "golden age" in the 16th and 17th centuries. Briefly a republic in 1873–74, Spain became one again in 1931. The leftist republican regime was overthrown in the Spanish Civil War (1936–39), however, and for 36 years Spain was ruled by the right-wing dictator Generalissimo Francisco Franco. Following Franco's death in 1975, Spain began the transition to a constitutional monarchy under Juan Carlos I. Spain's name is derived from its Latin name, Hispania, which may have come from the Phoenician *i-sch-phannim,* meaning "rabbits' coast."

Land and Resources

The second highest country in Europe (after Switzerland), Spain has an average elevation of 660 m (2,165 ft). Mulhacén, which rises to 3,478 m (11,411 ft) in the Sierra Nevada of southern Spain, is the highest point on the mainland; Pico de Teide (3,718 m/12,195 ft), on the island of Tenerife in the Canaries, is the highest point in Spain.

The dominant landform on the mainland is the Meseta (or Tableland), a broad plateau with an average elevation of 700–800 m (2,300–2,600 ft) in Old Castile and 600–700 m (1,968–2,300 ft) farther south in New Castile. The Cantabrian Mountains form the northern edge of the Meseta. To the northwest rise the hills and mountains of León and Galicia, and to the west rise the broken uplands of Estremadura that separate Spain from Portugal. The southern edge is formed by the Sierra Morena. To the east, beginning about 25 km (15 mi) east of Burgos, are the northwest-southeast trending Iberian Mountains.

To the north of the Meseta and its mountain rim are the Basque region and the Pyrenees, which mark the border with France and reach 3,404 m (11,168 ft) in Aneto Peak. To the south are the snowcapped Sierra Nevada and other ranges of the Betic Cordillera that stretch from Gibraltar to near Alicante and reappear offshore in the Balearic Islands. The two principal lowlands are the Ebro Basin, a structural depression between the Pyrenees, Iberian Mountains, and Catalan Mountains along the coast between Valencia and Barcelona; and the Guadalquivir (or Andalusian) Basin, between the Sierra Morena and Betic Cordillera in the south.

Soils. Spain's most fertile soils are of alluvial origin and occur along the major river valleys and on small coastal plains in Andalusia, Murcia, and Valencia. Red Mediterranean soils, suitable for cultivation, occur in Badajoz, Salamanca, Ciudad Real, Toledo, and Jaén.

Climate. Spain has three temperate types of climate. Mild, humid conditions, typical of northwestern Europe, prevail in the northwest, north, Pyrenees, and Central Mountains. A Mediterranean type of climate, with mild temperatures and dry summers, prevails along the Mediterranean littoral, in Andalusia, and in the Balearic Islands. A continental variant of the Mediterranean climate, with sporadic rainfall, cold winters, and hot summers, occurs in the northern Meseta, Ebro Basin, and other inland areas. Except in the north and in the mountains, rainfall is everywhere scanty; annual amounts decrease from between 600 and 1,000 mm (24 and 40 in) along the Cantabrian and Galician coasts to less than 600 mm (24 in) in the southern Meseta, Andalusia, and Mediterranean coastal regions and as little as 350 mm (14 in) in some inland areas.

Drainage. The longest rivers are the Tagus River, which crosses the Meseta to enter the Atlantic Ocean in Portugal, and the Ebro River, which flows into the Mediterranean. Other major rivers draining to the Atlantic are the Douro (Duero), Guadalquivir, Guadiana, and Miño.

Vegetation and Animal Life. Slightly more than 20% of Spain is forested. The principal trees in the north are beech, oak, chestnut, eucalyptus, and some pine and fir. A more open, evergreen type of forest with groves of holm oaks and cork oaks predominates in drier regions. Wild animals include Hispanic goats, boars, chamois, wolves, foxes, deer, and hares. Partridges and quail are common game birds, and storks, eagles, and vultures are sometimes seen.

Resources. About 35% of the land is cultivated; 7% is planted with permanent crops such as olives, wine grapes, and citrus; and 27% is used for pasture and meadow. Irrigation is practiced extensively. Fuel resources are inadequate, despite some deposits of bituminous coal, anthracite, lignite, petroleum, and natural gas. Most mineral deposits—of sulfur, mercury, gypsum, nickel,

AT A GLANCE

KINGDOM OF SPAIN

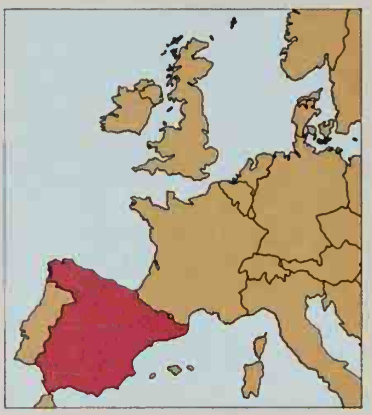
Land: Area: 504,782 km^2 (194,897 mi^2). Capital and largest city: Madrid (1987 est. pop., 3,100,507).

People: Population (1990 est.): 39,618,000. Density: 78 persons per km^2 (203 per mi^2). Distribution (1985): 76% urban, 24% rural. Official language: Spanish. Major religion: Roman Catholicism.

Government: Type: constitutional monarchy. Legislature: Cortes. Political subdivisions: 17 autonomous communities (comprising 50 provinces), 5 overseas enclaves.

Economy: GNP (1989): $358 billion; $9,150 per capita. Labor distribution (1987): services—20%; industry and mining—21%; agriculture—14%; trade—18%; construction—8%; other—19%. Foreign trade (1989): imports—$87 billion; exports—$54 billion. Currency: 1 peseta = 100 céntimos.

Education and Health: Literacy (1990): 97% of adult population. Universities (1989): 35. Hospital beds (1987): 195,772. Physicians (1989): 143,803. Life expectancy (1990): women—82; men—75. Infant mortality (1990): 6 per 1,000 live births.



copper, phosphates, potassium, lead, zinc, and uranium—lie in faulted areas surrounding the edges of the Meseta and are difficult to extract. Hydroelectric power is important.

People

The three principal regional minority groups are the Basques, who make up somewhat more than 2% of the total population; the Catalans, who make up about 16% of the population and live mainly on the east coast (see Catalonia); and the Gallegos (Galicians), who constitute about 8% of the population and are concentrated in the northwest.

Language. Spain's official language is Castilian Spanish, but Catalan, Basque, and Galician are important regional languages with their own literature. Catalan includes Valencian and Balearic as subtypes and is related to Provençal French. The Basque language is of unknown affinity; Galician is related to Portuguese.

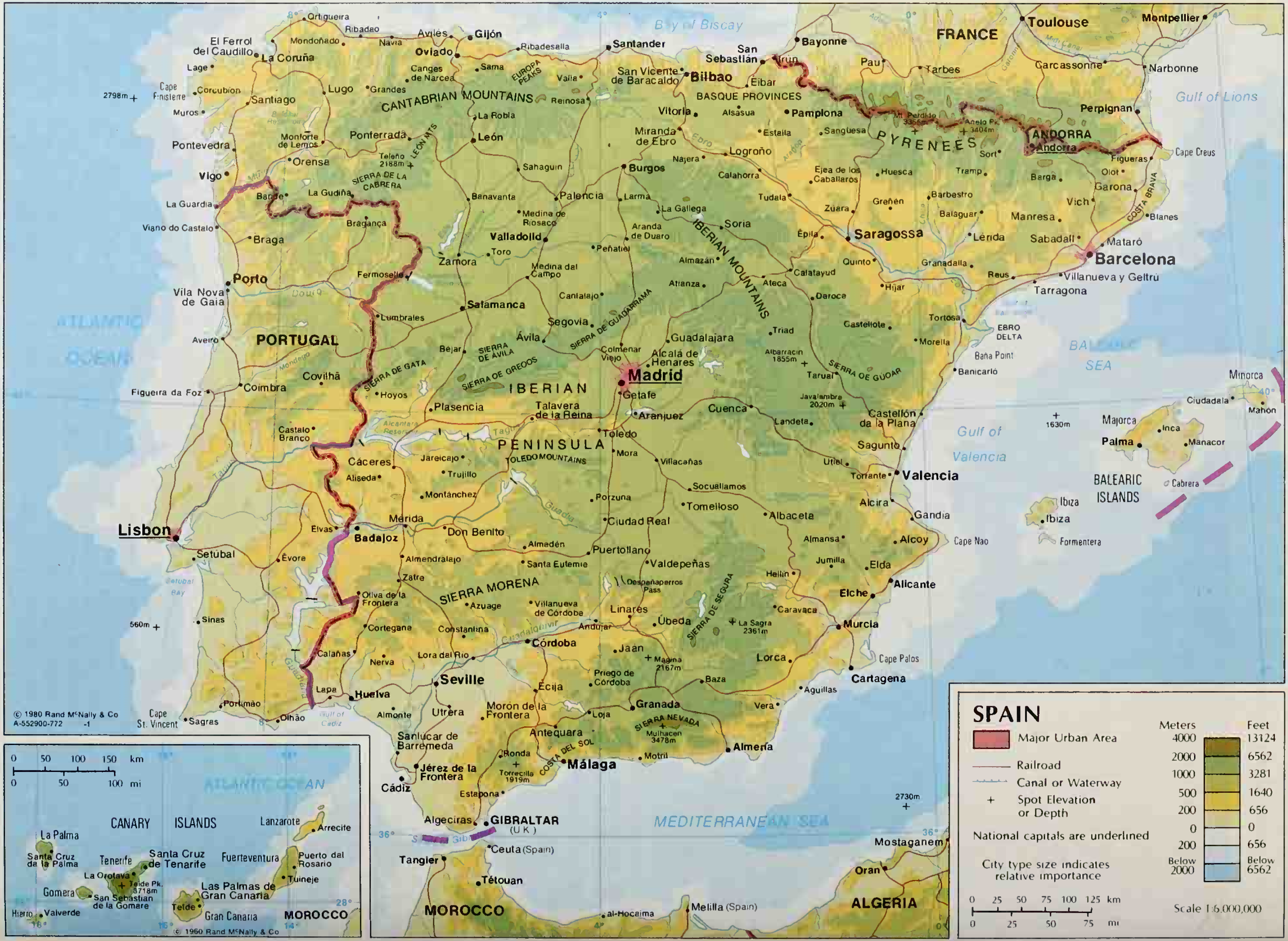
Religion. Roman Catholicism is the official religion, and about 99% of the people are baptized as members of that church. Fewer than 1% belong to Protestant groups and small communities of Jews and Muslims located in the larger cities.

Demography. The Spanish have long tended to live in defensible urban centers rather than scattered on the land. Rapid urbanization, however, did not take place until more recently. The two largest cities, each with considerably more than 1 million inhabitants, are Madrid and Barcelona. Other large cities are Valencia, Seville, Bilbao, Málaga, and Las Palmas. Population densities in Spain are generally lower than in most other parts of Europe.

Education and Health. The present educational system is based on laws adopted in 1970. The system provides for optional preschool education and 8 years of compulsory general basic education. Students thereafter may enter the 3-year *Bachiller* (B.U.P.) program, after which a 1-year college orientation program (C.O.U.) is required for entrance to a university. Higher education is structured in three cycles: the first cycle lasts 3 years, and the second and third cycles 2 years each. Major universities are located in Madrid and Barcelona, and there are regional universities in most larger cities. The number of public schools remains inadequate to serve the student population. Approximately one-third of all students attend private schools, the majority of which are administered by the Catholic church.

A compulsory national social security system covers more than 85% of the population. A network of government health centers has been established in the major cities.

The Arts. Cultural institutions are overseen by the Ministry of Culture, and official culture centers are located in the large urban centers and provincial capitals. Of special importance in Madrid are the Centro de Cooperación, Iberoamericana, the Ateneo, and the Villa de Madrid cultural center; several private foundations such as the March, Mediterránea, and Universitaria Española; and the Club Siglo XXI. For further discussion of the arts in Spain see Catalan literature, Spanish art and architecture, Spanish literature, and Spanish music.


SPAIN
Major Urban Area
Railroad
Canal or Waterway
Spot Elevation or Depth
National capitals are underlined
City type size indicates relative importance
Meters 4000 2000 1000 500 200 0 200 Below 2000
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Bay of Biscay
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BALEARIC SEA
Gulf of Valencia
MEDITERRANEAN SEA
IBERIAN PENINSULA
PYRENEES
CANTABRIAN MOUNTAINS
IBERIAN MOUNTAINS
SIERRA MORENA
SIERRA NEVADA
SIERRA DE GUADARRAMA
SIERRA DE GREDOS
SIERRA DE GATA
SIERRA DE ÁVILA
SIERRA DE SEGURA
SIERRA DE GUDAR
SIERRA DE LA CABRERA
LEÓN MTS
TOLEDO MOUNTAINS
EUROPA PEAKS
BASQUE PROVINCES
COSTA BRAVA
COSTA DEL SOL
BALEARIC ISLANDS
EBRO DELTA
ANDORRA
Andorra
GIBRALTAR (U.K.)
Ceuta (Spain)
Melilla (Spain)
Madrid
Lisbon
Barcelona
Valencia
Seville
Saragossa
Bilbao
Málaga
Porto
Toulouse
Montpellier
Narbonne
Carcassonne
Perpignan
Pau
Tarbes
Bayonne
Irún
San Sebastián
Eibar
Santander
San Vicente de Baracaldo
Vitoria
Alsasua
Pamplona
Estella
Sangüesa
Logroño
Miranda de Ebro
Burgos
Najera
Calahorra
Tudela
Ejea de los Caballeros
Huesca
Tramp
Sort
Barga
Olot
Figueras
Garona
Vich
Blanes
Manresa
Sabadell
Mataró
Villanueva y Geltrú
Tarragona
Reus
Lérida
Balaguer
Barbastro
Grañen
Zuera
Épila
Calatayud
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Hijar
Granadalla
Tortosa
Morella
Castellote
Daroca
Ateca
Triad
Albarracín 1855m
Teruel
Javalambre 2020m
Baña Point
Benicarló
Castellón de la Plana
Sagunto
Landete
Cuenca
Utiel
Torrente
Alcira
Gandia
Cape Nao
Alcoy
Elda
Alicante
Elche
Almansa
Jumilla
Hellín
Murcia
Caravaca
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Cartagena
Cape Palos
Lorca
Aguilas
Vera
Almería
Baza
Granada
Mulhacén 3478m
Motril
Jaén
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Úbeda
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Andújar
Córdoba
Priego de Córdoba
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Antequera
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Estepona
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Jérez de la Frontera
Cádiz
Sanlúcar de Barrameda
Utrera
Morón de la Frontera
Écija
Almonte
Huelva
Lepe
Calañas
Nerva
Lora del Río
Constantina
Cortegana
Oliva de la Frontera
Zafra
Azuaga
Villanueva de Córdoba
Almadén
Santa Eufemia
Puertollano
Valdepeñas
Despeñaperros Pass
Ciudad Real
Tomelloso
Socuéllamos
Albacete
Porzuna
Villacañas
Mora
Toledo
Aranjuez
Getafe
Alcalá de Henares
Guadalajara
Colmenar Viejo
Segovia
Ávila
Cantalejo
Atienza
Almazán
Soria
Aranda de Duero
La Gallega
Lerma
Peñafiel
Valladolid
Palencia
Medina de Rioseco
Medina del Campo
Toro
Zamora
Salamanca
Béjar
Plasencia
Talavera de la Reina
Jaraicejo
Trujillo
Montánchez
Cáceres
Aliseda
Mérida
Don Benito
Almendralejo
Badajoz
Elvas
Évora
Setúbal
Sines
Sagres
Cape St. Vincent
Portimão
Olhão
Castelo Branco
Covilhã
Coimbra
Figueira da Foz
Aveiro
Vila Nova de Gaia
Braga
Viano do Castelo
La Guardia
Barcelos
Bragança
Lumbrales
Fermoselle
Hoyos
Benavente
Sahagún
León
La Robla
Ponferrada
Teleno 2188m
Orense
Monforte de Lemos
La Gudiña
Vigo
Pontevedra
Muros
Corcubión
Cape Finisterre
Lage
Santiago
La Coruña
El Ferrol del Caudillo
Mondoñedo
Ortigueira
Ribadeo
Navia
Avilés
Oviedo
Gijón
Cangas de Narcea
Grandes
Lugo
Sama
Ribadesella
Valle
Reinosa
2798m
560m
1630m
2730m
Minorca
Ciudadela
Mahón
Majorca
Inca
Palma
Manacor
Cabrera
Ibiza
Formentera
Tangier
Tétouan
al-Hoceima
Oran
Mostaganem
Douro
Tagus
Guadiana
Guadalquivir
Ebro
Mondego
Alcántara Reservoir
CANARY ISLANDS
ATLANTIC OCEAN
0 50 100 150 km
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La Palma
Santa Cruz de la Palma
Tenerife
Santa Cruz de Tenerife
La Orotava
Teide Pk. 3718m
Gomera
San Sebastián de la Gomera
Hierro
Valverde
Gran Canaria
Las Palmas de Gran Canaria
Telde
Fuerteventura
Puerto del Rosario
Tuineje
Lanzarote
Arrecife
MOROCCO
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Economic Activities

Slow to industrialize in the 18th and 19th centuries, Spain remained predominantly agricultural until 1950. During Franco's rule, the state-run INI (National Industrial Institute) attempted to decrease imports and make Spain industrially self-sufficient by rapidly expanding petroleum refining, shipbuilding, automobile assembly, aeronautics, and the production of chemicals, fertilizers, petrochemicals, and electricity. With the 1959 stabilization program, private industry and foreign investment were again encouraged, and Spain grew rapidly under a series of economic development plans, although the per capita income remained less than that of most Western European countries. After 1975, efforts were made to reduce dependence on imported petroleum and to streamline inefficient industries to enable them to compete more efficiently in the European market. In 1986, Spain joined the European Community and is the fastest-growing member of the group. The main problem is unemployment (almost 20% in 1988), which is the highest in Europe.

Manufacturing and Mining. Industrialization made rapid strides in the second half of the 20th century. The auto industry, especially SEAT, the largest producer, employs the greatest number of workers. The iron-and-steel industry, centered in the north, is the leader in metal processing. Other major industries include shipbuilding, chemicals, cement, textiles, electronics, leather goods, toys, and furniture. The steel and shipbuilding industries suffered a steady decline in the 1980s, hurt both by world trade conditions and by outdated and inefficient facilities.

The most valuable mineral mined is mercury, followed by anthracite, bituminous coal, lignite, iron ore, sulfur, potassium chloride, fluorspar, lead, and zinc. Petroleum and natural gas are produced in small quantities, but Spain imports most of its petroleum.

The Alhambra, located on a ridge overlooking the Andalusian city of Granada in southeastern Spain, was begun in 1238 when Granada became the capital of the last Moorish kingdom in Spain. This fortified palace became the center of Moorish arts and learning.

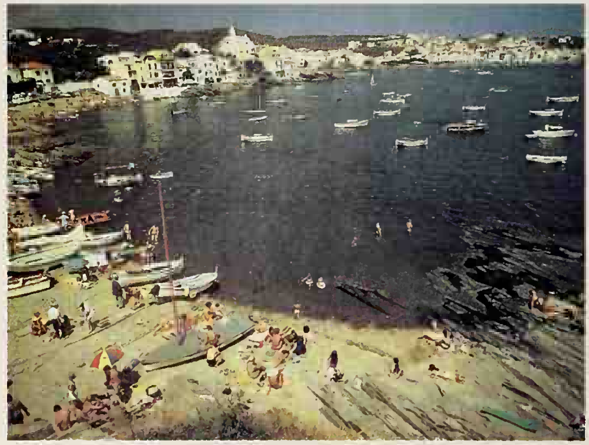
The Plaza de la Cibeles in central Madrid is lined with the banks and business establishments of the city's principal commercial district. A leading manufacturing city and the center of Spanish government, Madrid has become Spain's most populous city.

Energy. In an effort to lessen the country's dependence on imported oil, an attempt has been made to increase coal production and expand nuclear-power capability. This program has met with considerable success: coal production increased markedly between 1980 and 1987, and nuclear power provided more than 36% of Spain's energy needs in 1988.

Agriculture. Cereals occupy more than 60% of the cultivated area, with wheat and barley the main crops. In general, rainfall in inland and southern regions is not sufficient for diversified farming, and the lands are either dry-farmed or irrigated. Unirrigated areas are traditionally planted to wheat one year and left fallow the next, although this low-yielding method of cultivation is being replaced by a triennial rotation based on cereals the first year, a soil-enriching leguminous crop the second year, and a fallow third year. Spain is the world's largest producer of olives and one of the largest producers of wines. Irrigated agriculture in the Ebro Basin, Douro Valley, Guadalquivir Basin, and lowlands along the Mediterranean produces high yields of citrus and other fruits, vegetables, sugar beets, cotton, and tobacco. Some beef and dairy cattle are raised but are greatly outnumbered by sheep and pigs.

Forestry and Fishing. Lumber, cork, and resin are the leading forest products. Fishing has traditionally been important, and Spain's fishing fleet remains one of the world's largest. The catch consists mainly of hake, sardines, and tuna.

Transportation. Almost half of all roads are suitably surfaced for modern traffic, but few are superhighways. The railroads are operated by Spanish National Railways (RENFE). The rail network is less dense than in other European countries, but a major upgrading program is under



Fishing boats and bathers share a beach on the Costa Brava, or "wild coast," of Spain's northern Mediterranean shore. Although fishing was long the principal source of income, tourism is now more important to the area's economy.

way. Air transportation is dominated by nationally owned Iberia and Aviaco airlines. The main airports are in Madrid, Palma de Mallorca, Barcelona, Las Palmas, Málaga, Santa Cruz de Tenerife, and Alicante. The busiest ports are Bilbao, Santa Cruz de Tenerife, Cartagena, La Coruña, Santander, and Málaga.

Trade. The main exports are iron and steel products, motor vehicles, machinery, appliances, shoes and leather items, electrical goods, and refined-petroleum products. Agricultural products now constitute less than a third of all exports, with citrus fruit, canned fish and vegetables, wines, olive oil, and fresh vegetables the most important. The principal imports are petroleum, basic chemicals, machinery and equipment, and food products (mainly coffee and tea). More than 50% of all exports go to member countries of the EC and to the United States.

Government

According to the 1978 constitution, Spain is a hereditary, constitutional monarchy with a parliamentary form of government. King Juan Carlos I came to the throne in 1975. The prime minister is Felipe González Márquez, whose Socialist party won the national elections in 1982, 1986, and—with a weakened showing—1989. Executive power rests with the king, the prime minister, and the council of ministers. Legislative power is invested in the Cortes, consisting of the Congress of Deputies and the Senate. Elections are held every 4 years.

Spain is divided into 50 provinces, each with an appointed governor and a local council. Demands for autonomy from the Basques and Catalans, with their own languages and traditions, have led to the creation of regional self-government.

Spain, history of Isolated by seas and mountains from many of the main currents of European culture, subject to conquest from Africa, and possessing ready access to the Atlantic Ocean and the wealth that lay beyond it, the Spanish have a rich and varied national experience that highlights and yet diverges from many of the important developments in European history.

To the Muslim Conquest

Spain has been inhabited for probably half a million years. Of all the remains of Stone Age peoples, none is more impressive than the polychrome paintings of bison, horses, and other animals in the caves at Altamira (in Santander, on the Bay of Biscay) from about 15,000 years ago.

An agricultural revolution came to Spain about 3000 BC. In the south of Spain many dolmens and megalithic tombs have survived, attesting to the vitality of this culture, called the Almería. About 1000 BC waves of migrants began to bring in new cultural influences. Celts, people speaking an Indo-European language, entered from the north, and settlers from more advanced civilizations founded towns on the Mediterranean coast: Phoenicians at Cádiz, Greeks at Málaga and Ampurias, and Carthaginians at Cartagena.

Roman Conquest. In 218 BC, at the beginning of the Second Punic War, the Romans invaded Iberia but Roman control of the Iberian Peninsula was not complete until 19 BC. The peninsula became one of the empire's most valuable provinces as Spanish gold, silver, copper, iron, tin, and lead enriched Rome. Most Iberians learned Latin and acquired Roman citizenship. Of the many structures built by Roman engineers, the aqueduct of Segovia, the theater of Mérida, and the bridge of Córdoba are still standing.

Visigothic Spain. Early in the 5th century the Roman Empire was invaded by Germanic barbarians. Among those who settled in Spain were Vandals (who gave their name to Andalusia) and Visigoths (see Goths). The latter, migrating from France and numbering fewer than 250,000, were able to dominate 6 or 7 million Hispano-Romans. During the reign (r. 568–86) of King Leovigild the Visigoths moved their capital from France to Toledo. Leovigild conquered the Suevi and Basques and allowed intermarriage between Visigoths, who were Arian Christians (see Arianism), and Hispano-Romans. King Reccared (r. 586-601) converted the Visigoths to Catholicism.

King Reccesvinth (r. *c.*649-72) promulgated a legal code that was based largely on Roman precedents. The Visigothic monarchy, however, was generally weak; because their position was elective, the kings were continually subject to the intrigues of their nobles. In 711 the family of the late King Witiza (r. 701–*c.*710) asked the Muslims of Morocco to help them overthrow King Roderick (r. 710–11). The Muslim general Tariq ibn Ziyad (fl. 711) crossed over to Gibraltar, defeated Roderick, and—taking advantage of divisions among the Visigoths—began the conquest of Spain.

Muslim Spain and the Reconquest

By 718 the Muslims were masters of almost the entire peninsula. The rich lands of southern Spain, which they

A miniature from the 13th-century Cántigas de Santa María *portrays the fighting between the Christian Visigoths and the Muslims who overran most of Spain beginning in* AD *711. (Escorial, Madrid.)*

called al-Andalus, were especially attractive in comparison to the deserts of North Africa. Few Muslims—or Moors, as the Christians called them—chose to settle on the barren highlands of Castile.

Al-Andalus. The UMAYYAD dynasty, whose first ruler was ABD AL-RAHMAN I, ruled al-Andalus from 756 to 1031. Abd al-Rahman III (891–961) reunited Moorish Spain and declared himself caliph of Córdoba. His reign (929–61) marks the apogee of Muslim Spain, a time of economic and cultural splendor.

Al-Andalus contrasted sharply with Christian Europe. At a time when Europe had become rural and impoverished, al-Andalus was a region of prosperous cities and intense trade. Its goods—including glass, paper, leather, metalwork, and silk—were renowned as far away as India. The Muslim rulers generally tolerated Christians and Jews and encouraged cultural diversity. Science, medicine, and philosophy flourished. Spanish Islamic scholars such as AVERROËS (1126–98) studied the works of Aristotle and other Greeks, which were translated into Latin and eventually spread to the rest of Europe.

After the death in 1002 of the dictator al-Mansur, al-Andalus broke up into small, quarreling factional states. It was briefly reunited by North African Muslim invaders, the Almoravids (1086–1147) and the Almohads (1147–1212), but despite temporary successes, however, Muslim Spain was already on the defensive.

Rise of the Christian Kingdoms. The few Christian enclaves that the Muslims allowed to survive in the north had meanwhile grown into powerful kingdoms. In ASTURIAS, on the Bay of Biscay, a group of Visigoth nobles elected Pelayo (r. *c.*718–37) their king. Pelayo's victory (*c.*722) over a Muslim army was later hailed as the beginning of the Reconquest of Spain. The discovery (*c.*815) of the alleged tomb of Saint James at SANTIAGO de Compostela enhanced Asturian prestige.

In the northeast of the peninsula, Frankish warriors under CHARLEMAGNE established the Spanish March, embryo of a future CATALONIA. Between this region and Asturias the kingdom of NAVARRE rose to prominence in the 10th century. King SANCHO III, the Great, of Navarre briefly ruled (1000–35) all Christian Spain, although his empire was later divided among his four sons. Under Sancho, European influences—such as the Cluniac monastic reform and feudalism—were able to permeate Spanish society.

Most significant in laying the foundations of modern Spain were ARAGON and CASTILE. Aragon became an independent kingdom when Ramiro I (r. 1035–63) received it from his father, Sancho the Great. Aragon expanded its territory and in 1137 added mercantile Catalonia. Thereafter, while the two regions remained distinct, they were linked under the crown of Aragon. The Aragonese kings extended their rule to the Balearic Islands (1230–86), Valencia (1238), and, at different periods, to Sardinia, Sicily, and Naples.

Castile, situated on La Mancha tableland in the center of the peninsula, provided the central driving force for the Christian Reconquest. Originally an autonomous county subject to the kingdom of León, Castile lay on the frontier with Islam, where a bellicose, dynamic society developed in which warriors, such as EL CID Campeador, achieved great power and wealth. By 1188, King Alfonso VIII (r. 1158–1214) had asserted Castilian superiority. At that time Castile had already pushed the frontier far to the south and was identified in the rest of Europe as Spain; foreigners called its language Spanish. The Castilians adopted an intense Christianity. When added to the fanaticism of the Almoravid enemy, this devotion transformed the Reconquest into a religious crusade. In 1212, Castile, decisively defeated the Almohads at Las Navas de

The Castilian warrior known as El Cid Campeador, "the lord conqueror," served both Castilian and Moorish rulers before conquering (1094) Valencia and establishing himself as a ruler.

Tolosa, and by 1248 only Granada was in Muslim hands.

The Reconquest was completed with the taking of Granada in 1492. During the 14th and 15th centuries, Aragon and Castile became more involved in European affairs, including the Hundred Years' War, and fought against each other and Portugal, a separate kingdom since 1112, and Navarre. In the struggle between the Castilian monarchy and the nobles, the crown usually depended on the support of the towns, which had representatives sitting in the parliament (Cortes) and military associations (*hermandades*) policing the countryside. Ultimately, however, the monarchy subjected the clergy, towns, and even the great nobility to its will.

Spain during the Sixteenth Century

The Reign of the "Catholic Kings." By a chance of dynastic fortune—the accession of ISABELLA I to the throne of Castile in 1474 and of her husband FERDINAND II to that of Aragon in 1479—the two most important kingdoms of Spain were joined. The "Catholic kings," as they are known, were both exceptionally gifted.

Isabella sought to centralize power, using the church as her instrument. In 1480 the Spanish INQUISITION began interrogating suspected heretics and converted Jews, whose financial activities had made them unpopular; in 1492 all Jews were expelled from Spain. The Inquisition thus helped identify Spain with orthodox Catholicism. Also in 1492, Granada was conquered, ending the Reconquest, and Christopher COLUMBUS, sailing with the financial backing of Spain, discovered America.

Ferdinand, meanwhile, had turned his attention to the conquest of Naples, and he also added Navarre and territories on the French border to the family's domains. On his death in 1516—Isabella had died in 1504—both of their crowns went to their grandson Charles I.

The Habsburg Monarchs. Hardly had Charles set foot in his new kingdoms when he was elected Holy Roman Emperor CHARLES V and departed for Germany. For the next two centuries the fate of Spain was tied to that of the HABSBURG dynasty. At the beginning of Charles's reign his foreignness made him unpopular in Spain, but later he won the loyalty of his subjects. He also adopted his grandparents' ideals of Catholic unity and imperial conquest, financed by wealth from the New World. He was backed in these goals by the JESUITS, founded in 1540.

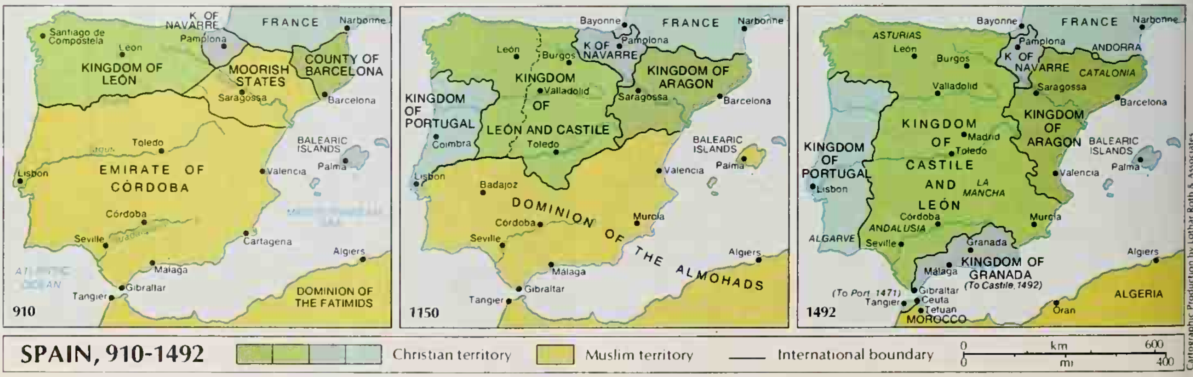
Columbus's discoveries were followed by Hernán CORTÉS's conquest of Mexico (1519–21) and Francisco PIZARRO's of Peru (1531–33). The resulting influx of gold and silver from America, however, tended to undermine Spain's domestic industry, encouraging not only inflation but also a spirit that valued bravery and piety over hard work. Taxation and warfare also contributed to the Castilian economy. Nonetheless, the wealth of the New World was sufficient to make Spain the greatest European power of the age.

PHILIP II, Charles's son and successor, was hated by Spain's enemies but was enormously popular among his people. He entangled Spain in ruinous wars in the Netherlands (see DUTCH REVOLT), and in 1580 he acquired Portugal. This union brought upon the Portuguese colonies and sea routes the attacks of Spain's Dutch and English enemies and increased Portuguese hostility toward the king. Philip's reign was marked by two crucial naval encounters, one ending in victory and the other in defeat. The Ottoman Empire was stopped in 1571 at the Battle of LEPANTO, but in 1588, when Philip attempted to invade England, his "invincible" SPANISH ARMADA was destroyed by storms and English ships.

Spain, 1598–1814

When the 17th century began, Spain was at the peak of its cultural splendor, epitomized by Miguel de CERVANTES and Lope de VEGA in literature and EL GRECO and Diego VELÁZQUEZ in art. By the end of the century, however, the country's economic and political power had declined drastically, and cultural leadership among the

(Left) *The Moorish (Muslim) principalities in Spain, established after the rapid conquest of the peninsula during the 8th century, were largely united during the 10th century under the Umayyad Emirate (later Caliphate) of Córdoba.* (Center) *Fragmentation of this state aided the reconquest by the Christian kingdoms of northern Spain.* (Right) *Despite resurgences under the Almoravid and Almohad dynasties, Muslim power was reduced by sporadic victories from the Battle of Las Navas de Tolosa (1212) to the fall of Granada (1492).*



Cartographic Production by Lothar Roth & Associates

Philip II, heir to the Spanish domains of Charles V, sought to consolidate a Catholic empire through suppression of revolts in the Netherlands (1576) and Granada (1568–71) and by use of the Inquisition. Philip's military expenditures and the defeat (1588) of the Armada by the English considerably weakened the Spanish empire.

nations of Europe had passed to France.

Decline of Spanish Glory. Spain's downfall was due in part to a succession of unfit kings whose favorites brought mismanagement and corruption into government. PHILIP III (r. 1598–1621) left the work of government to his favorite, the duque de Lerma (1553–1625). Lerma's successors dragged Spain into the THIRTY YEARS' WAR (1618–48). Under PHILIP IV (r. 1621–65), a notable patron of the arts, the brilliant but tactless conde-duque de OLIVARES prosecuted the war strenuously. Despite spectacular early victories, French arms ultimately confirmed Spain's military decline. Meanwhile, Olivares's centralizing efforts led to rebellions in 1640 in Portugal and Catalonia. Portugal regained its independence, and Catalonia came under French control until 1652. Habsburg rule ended in Spain with the infirm CHARLES II (r. 1665–1700).

The Spanish Bourbons. The 18th century opened with the War of the SPANISH SUCCESSION (1701–13), by which Louis XIV of France put his grandson, who became PHILIP V, on the throne against English and Dutch opposition. The early Bourbons—Philip (r. 1700–46), FERDINAND VI (r. 1746–59), and CHARLES III (r. 1759–88)—were more capable than their recent Habsburg predecessors. Government administration became more rationalized and centralized, and greater attention was given to fostering economic development. The Bourbons also quickly achieved what Olivares had long pursued: the destruction of the special privileges enjoyed by Catalonia, Aragon, and Valencia. Spain had become a union of provinces instead of a collection of kingdoms.

With the introduction of ENLIGHTENMENT ideas—particularly under Charles III—came pressures for secularization. In 1767 the Jesuits were expelled from the empire. At the same time the powers of the Inquisition were reduced.

In foreign policy, Philip's marriage to an Italian, Elizabeth FARNESE, led to territorial ambitions in Italy. Ferdinand, in contrast, brought peace by remaining neutral in Anglo-French conflicts. Charles, a prime example of an enlightened despot, paid considerable attention to the American empire, even establishing imperial free trade in 1778. He was convinced, though, that England was the major threat to Spanish America and formed a family compact with France, thus involving his country in the SEVEN YEARS' WAR (1756–63) and the AMERICAN REVOLUTION (1776–83).

The French Revolutionary and Napoleonic Periods. CHARLES IV (r. 1788–1808), a weak and unintelligent man, was dominated by Manuel de GODOY, his prime minister after 1792. When the French Revolution started in 1789 the frightened government tried to seal Spain off from revolutionary ideas and stopped all reform plans, but in 1793, Spain was crushed, and by 1796 it had become essentially a French satellite. Spain suffered from English attacks on its empire and shipping, and a Franco-Spanish fleet was destroyed by the British at the Battle of TRAFALGAR in 1805. NAPOLEON I persuaded Godoy in 1807 to allow French troops to cross Spain in order to conquer Portugal.

Aristocratic and popular resentment turned against Godoy and Charles. In March 1808 a riot, stirred up by Charles's son, forced the king to abdicate in favor of this son, who took the throne as FERDINAND VII. In May, Napoleon induced Charles and Ferdinand to meet him in France, forced them both to give up their claims to the throne, and then installed his brother Joseph Bonaparte as king of Spain (see BONAPARTE family). The Spanish people rose up against France's occupying army, helping to set off the Peninsular War (see NAPOLEONIC WARS). The French, under Napoleon's personal direction, reconquered the peninsula, except Portugal and Cádiz, by 1810. Continued guerrilla warfare, however, weakened the French, while British general Arthur Wellesley (later duke of WELLINGTON) advanced from the west. Opposition to the French also forced the Spanish people to adopt their own governmental forms in the absence of the king and a large part of the nobility. Dominated by the bour-

Francisco de Goya's The Executions of May 3, 1808 *(1814) depicts savage French reprisals against the popular uprising in Madrid. The French invasion of Spain, perpetrated as a strategic maneuver against Portugal, led to the 6-year Peninsular War. (Prado, Madrid.)*

geoisie, the cortes of Cádiz proclaimed a democratic constitution in 1812. After Wellington's victory at Vitoria in 1813 forced the French to leave, however, Ferdinand returned (1814) to the Spanish throne.

Spain, 1814 to the Present

Spain in 1814 had been reduced to the status of a minor underdeveloped nation on the periphery of a fast-industrializing Europe. Economic recovery was retarded for decades by the lack of a capitalist bourgeoisie and by political turmoil.

Period of Turmoil: 1814–75. Ferdinand proved to be a vindictive reactionary whose brutality led to a liberal revolutionary interlude (1820–23). When he died the First Carlist War (1833–39) broke out between the liberal supporters of his daughter Isabella II (r. 1833–68) and the Carlists, the reactionary followers of his brother Don Carlos. The victorious liberals nationalized and sold church lands, creating new landowners who supported the conservative political group known as the Moderates. During the Moderate era (1843–68) many military men became prominent in party leadership positions, and three more constitutions were adopted. Meanwhile, Isabella continued in her attempts to impose despotic rule on Spain.

In 1868 a military uprising under generals Juan Prim and Francisco Serrano (1810–85) forced Isabella into exile and triggered sharper conflicts at home. As the government changed from monarchy to republic to monarchy in six years, revolts of Federalists, Carlists, and Cubans threatened to break Spain into pieces.

The Bourbons Restored. The government created by the conservative statesman Antonio Cánovas del Castillo (1828–97) for the restored Bourbon Alfonso XII (r. 1874–85) rested on popular exhaustion, fear of revolution, and electoral manipulation. For about 20 years Cánovas's party alternated in power with the Liberals, and the ensuing peace, combined with free trade, brought some economic development. At the same time, the labor movement developed rapidly along socialist and anarchist lines. By the 1890s republicanism was again a growing force.

The peaceful era of Cánovas ended when he was assassinated in 1897. The following year Spain lost its last remaining colonies—Cuba, Puerto Rico, and the Philippines—in the Spanish-American War. This disaster caused much soul-searching by José Ortega y Gasset, Miguel de Unamuno, and other intellectuals of the "Generation of '98" who began a reinterpretation of Spanish history. An attempt to regain prestige through imperialism led only to a long, bitter war in northern Morocco (1909–25). Meanwhile, King Alfonso XIII came of age in 1902, after a regency of his mother. In 1917 a wave of strikes and terrorism exploded in Barcelona, army officers formed military unions, and no governing cabinet lasted long enough to impose order.

Alfonso XIII was rescued by a military uprising, and in September 1923, Gen. Miguel Primo de Rivera became dictator. Initially popular, he defeated (1925) the Moroccans—with French aid—but his attacks on intellectuals, financial mismanagement, and a severe economic depression forced him to leave Spain in 1930. The king followed him in 1931.

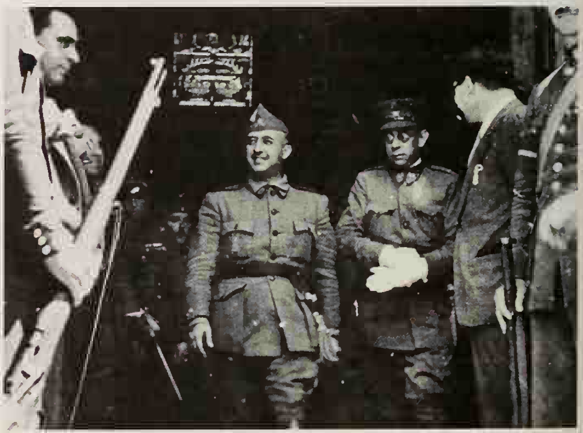
Republican Spain and the Rule of Francisco Franco. The Second Spanish Republic (1931–39) was notable for the intense participation in politics that it generated among people of all classes. Spain became polarized into two opposing blocs: on the right were the church, the army, the landowners, and aligned against them were workers, landless peasants, intellectuals, and most Catalans and Basques. Many reforms were initiated during the first two years of the republic, but from 1933 to 1936, a conservative government undid its predecessor's reforms and mercilessly crushed workers' uprisings. After February 1936 a leftist coalition threatened to bring about a social revolution. A conspiracy of conservatives and officers turned to rebellion in July 1936.

In the ensuing Spanish Civil War (1936–39), the Nationalists under Gen. Francisco Franco quickly conquered the western half of Spain. The Republicans—divided into Socialists, Anarchists, and Communists—often fought among themselves. Despite heroic resistance, some Soviet aid, and the participation of foreign volunteers, the republic crumbled before the slow advance of Franco's army into the industrial provinces of the east. The war may have cost Spain up to a million people, including émigrés as well as those killed.

Franco proved to be a harsh but flexible ruler. His regime began as a repressive totalitarian system supported by the army, the church, and the Falange (the official state party), but it survived World War II by remaining neutral. In 1947, Spain was declared a monarchy, with a king to be named to succeed Franco. After years of international isolation, Spain signed (1953) a concordat with the Vatican and became a member of the United Nations in 1955.

Franco agreed to substantial economic liberalization in the 1960s, and modern Spain has become more Europe-

Generals Francisco Franco (left center) *and Emilio Mola* (right center), *leaders of the military uprising (1936) that precipitated the Spanish Civil War, appear in this 1936 photo. Franco's 1939 victory initiated his 36-year rule.*



an than ever. After Franco's death in 1975, King JUAN CARLOS I and Premier Adolfo SUÁREZ GONZÁLEZ introduced political reforms. In 1981, Suárez was succeeded by Leopoldo Calvo Sotelo. An attempted military coup that year was easily suppressed, and Spain's transition from dictatorship to democracy was confirmed by Socialist victories in the national elections of 1982 and 1986. The Socialist premier, Felipe GONZÁLEZ MÁRQUEZ, won support by his moderate policies. He led Spain into the European Community and waged a successful campaign to keep the country in the NATO alliance.

RULERS OF SPAIN

	Castile and León		
Ferdinand I (León, 1037–65)	1035–65	Henry I (Castile only)	1214–17
Sancho II (Castile only)	1065–72	Ferdinand III (León, 1230–52)	1217–52
Alfonso VI (León, 1065–1109)	1072–1109	Alfonso X	1252–84
Urraca	1109–26	Sancho IV	1284–95
Alfonso VII	1126–57	Ferdinand IV	1295–1312
Sancho III (Castile only)	1157–58	Alfonso XI	1312–50
Ferdinand II (León only)	1157–88	Peter the Cruel	1350–69
Alfonso VIII (Castile only)	1158–1214	Henry II of Trastamara	1369–79
Alfonso IX (León only)	1188–1230	John I	1379–90
		Henry III	1390–1406
		John II	1406–54
		Henry IV	1454–74
		Isabella I	1474–1504
	Aragon		
Ramiro I	1035–63	Alfonso III	1285–91
Sancho Ramirez	1063–94	James II	1291–1327
Peter I	1094–1104	Alfonso IV	1327–36
Alfonso I	1104–34	Peter IV	1336–87
Ramiro II	1134–37	John I	1387–95
Petronilla	1137–62	Martin I	1395–1410
Alfonso II	1162–96	Ferdinand I	1412–16
Peter II	1196–1213	Alfonso V	1416–58
James I	1213–76	John II	1458–79
Peter III	1276–85	Ferdinand II	1479–1516
	UNIFIED KINGDOM		
Habsburg Dynasty		**Bourbon Dynasty**	
Joan the Mad	1504–06	Philip V	1700–24
Philip I	1506	Louis I	1724
Charles I	1516–56	Philip V	1724–46
Philip II	1556–98	Ferdinand VI	1746–59
Philip III	1598–1621	Charles III	1759–88
Philip IV	1621–65	Charles IV	1788–1808
Charles II	1665–1700	Ferdinand VII	1808
	Since 1808		
Joseph Bonaparte (king)	1808–13	Alfonso XIII (Bourbon king)	1886–1931
Ferdinand VII (Bourbon king)	1814–33	Niceto Alcalá Zamora y Torres (president, Second Republic)	1931–36
Isabella II (Bourbon queen)	1833–68	Manuel Azaña (president, Second Republic)	1936–39
Francisco Serrano (regent)	1869–70	Francisco Franco (general and dictator)	1939–75
Amadeus (elected king)	1870–73	Juan Carlos I (Bourbon king)	1975–
First Republic	1873–74		
Alfonso XII (Bourbon king)	1874–85		

Spalding, Albert Goodwill Sometimes mistakenly credited with inventing the game of baseball, Albert Goodwill Spalding, b. Bryan, Ill., Sept. 2, 1850, d. Sept. 9, 1915, was nevertheless an important figure in that sport's history. Spalding was a professional pitcher during the early 1870s when, in 5 seasons, he is said to have won 207 games. In 1876 he helped to found the National League. That same year he established the A. G. Spalding and Brothers sporting goods company. Spalding was elected to baseball's Hall of Fame at Cooperstown, N.Y., in 1939.

Spangenberg, Augustus Gottlieb [spahng'-en-bairk] Augustus Gottlieb Spangenberg, b. Prussia, July 15, 1704, d. Sept. 18, 1792, a bishop (1744–90) of the MORAVIAN CHURCH and its leader from 1762, founded the first Moravian settlements in North America. Sent from his native Germany, Spangenberg conducted missionary work in Georgia (1735); worked in Pennsylvania (1736–39), establishing a communal society at Bethlehem; and directed mission work in North Carolina in the 1750s. In 1762, Spangenberg returned to Germany to lead the denomination following the death of his predecessor, Graf von ZINZENDORF.

Spanish-American War The Spanish-American War (1898) marked the emergence of the United States as a great power and the advent of American overseas imperialism.

The explosion of the U.S. battleship Maine *in Havana harbor on Feb. 15, 1898, helped precipitate the Spanish-American War. Although Spain denied responsibility for the explosion, the American public, encouraged by the press, urged U.S. intervention.*

The Battle of San Juan Hill, fought on July 1, 1898, on the outskirts of Santiago de Cuba, established the popular reputation of the "Rough Riders" under Theodore Roosevelt and Leonard Wood.

During the 19th century, American exponents of MANIFEST DESTINY likened Cuba, a Spanish colony, to a ripening fruit destined ultimately to fall into outstretched American hands. The expansionists' hunger intensified after 1895, when Cuban nationalists began a bloody insurrection against the Spanish colonial government. Spain's ruthless Gen. Valeriano Weyler herded Cuban farmers into squalid concentration camps. Many men, women, and children died, and Weyler was dubbed "butcher" by William Randolph Hearst's sensationalist *New York Journal.* This and other "yellow" journals (see YELLOW JOURNALISM) editorialized for humanitarian intervention and the annexation of Cuba by the United States. On Feb. 9, 1898, Hearst published a purloined private letter in which the Spanish minister to the United States sharply criticized President William MCKINLEY; on February 15, the U.S. battleship MAINE exploded in Havana harbor. The drift toward war soon became inexorable. On April 11, McKinley in effect requested a declaration of war, which Congress passed on April 25.

The Fighting. Combat lasted only 10 weeks, but it proved one-sided and decisive. In the Pacific, Commodore George DEWEY's squadron slipped into Manila harbor and on May 1 destroyed the obsolete Spanish fleet lying at anchor. Reinforced by the army in June, Dewey captured Manila on August 13. In July—to support these combined operations—the U.S. Navy had seized Spanish Guam and previously unclaimed Wake Island, and Congress by joint resolution had annexed Hawaii.

In the Caribbean, Spanish ships under Adm. Pasqual Cervera were blockaded in the harbor of Santiago de Cuba by U.S. naval forces. U.S. troops under Gen. William R. SHAFTER landed in Cuba in late June and pressed toward Santiago. These ground forces included the regular army as well as special volunteer regiments, the most famous of which were the ROUGH RIDERS, led by Theodore ROOSEVELT and Leonard WOOD. The Americans were victorious at the battles of El Caney and San Juan Hill on July 1. Cervera made a dash for the open sea on July 3, but the guns of the new battleships and cruisers commanded by Rear Adm. William T. SAMPSON and Commodore Winfield Scott Schley sank most of the Spanish ships in less than 4 hours. On July 17, Cuba's 24,000 Spanish troops surrendered. Madrid sued for peace 9 days later.

The Treaty of Paris. During the peace negotiations the United States did not seek annexation of Cuba because the Teller Amendment to the declaration of war forbade American acquisition of the island. However, McKinley demanded Spanish cession of Puerto Rico, Guam, and the Philippine Islands. In the Treaty of Paris, concluded on December 10, a humiliated Spain yielded to American imperialism.

The imperialistic grab was not universally popular in the United States, and the Senate fight over the treaty was intense. By the narrow margin of 57 to 27 (only 2 votes more than the number needed for ratification) the Senate approved the pact on Feb. 6, 1899.

The "splendid little war" established the United States as a major power in the Far East and the dominant power in the Caribbean. Although Filipino nationalists fought a bitter 4-year struggle for immediate independence, the United States clung to the archipelago because it seemed a portal to the China market. Puerto Rico became an American colony and the site of an American naval base, and nominally independent Cuba ceded territory for naval stations to the United States under the terms of a constitution—with the so-called PLATT AMENDMENT appended to it—imposed by the American Congress and Secretary of War Elihu ROOT. These two islands were strategically significant to the defense of the Panama Canal, which was begun in 1904.

Spanish Armada The Armada was a great Spanish fleet assembled in 1588 as part of the attempt by PHILIP II to invade England. Philip had come to believe that only conquest could halt English aid to the rebels against Spain in the Low Countries or stop the English depredations in the New World. The plan, which proved beyond Spain's logistical capabilities, was to send a fleet of 130 ships to cover an invasion force from Flanders under Alessandro FARNESE.

When the inadequately provisioned Armada appeared off Plymouth on July 30, it was met by an English fleet of equal or superior strength. In spite of the efforts of Francis DRAKE, Martin FROBISHER, John HAWKINS, and other English captains, the Spanish maintained their order of battle and lost only two ships before arriving at Calais. The rendezvous with Farnese failed, however. Then, on August 8, English fire ships drove the Armada out of its Calais anchorage. The Spanish regrouped and fought another action off Gravelines, but they were now out of ammunition. Realizing that the situation was lost, the duke of Medina Sidonia, who commanded the fleet, sailed north around Scotland and Ireland and returned to Spain.

The defeat of the Armada did not affect the naval balance of power: England had been a major sea power before 1588, and the Spanish fleet was quickly rebuilt. It did demonstrate, however, that Spain lacked the power to impose religious unity on Europe.

Spanish art and architecture

Spanish art and architecture As both the western boundary of the Mediterranean Sea and the link between Africa and Europe, Spain has been repeatedly invaded and colonized since prehistoric times. Iberians, Basques, Celts, Romans, Visigoths, and Moors all contributed to Spanish painting, sculpture, and architecture. Because of Spain's great colonial expansion in the 16th century, the Spanish art of the Renaissance and Baroque periods had a strong influence on the artistic development of other parts of the world, especially of Latin America.

Prehistoric and Pre-Roman Art

For a period of several thousand years during the later Paleolithic Period, cave dwellers in northern Spain and southern France painted animals on the walls of caves and scratched drawings on bones. These examples of PREHISTORIC ART culminated in works of the middle Magdalenian period (*c.*12,000 BC) at ALTAMIRA, where astonishingly lifelike bison, horses, deer, and other animals cover the low cave ceilings. The Neolithic Period (*c.*2000 BC) saw the development of geometrically decorated pottery and megalithic dolmens—primitive stone structures that preceded the well-constructed dwellings and towers of the Bronze Age (*c.*1500 BC).

An abundance of sculpture, pottery, and jewelry has been found in the coastal areas colonized by the Phoenicians, Carthaginians, and Greeks. Surviving masterworks are the great bronze bulls' heads (6th century BC; Museo Arqueológico Nacional, Madrid) excavated at Costitx on the island of Mallorca and the Phoenician-influenced polychrome stone bust of the regal *Dama de Elche* (*c.*400 BC; Prado, Madrid).

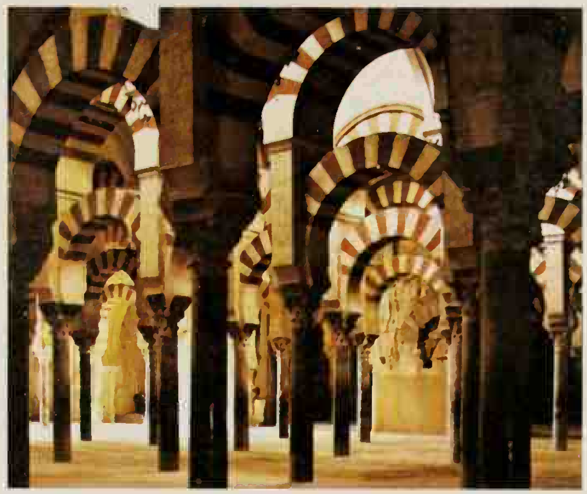
Roman and Early Christian Art

Rome colonized Spain beginning in the 3d century BC, and many cities still retain Roman walls, bridges, or aqueducts. Mérida is a veritable Roman museum. At Italica, near Seville, a Roman town has been excavated, revealing fine mosaics.

The spread of Christian and Byzantine influence in Spain from the 4th to 7th centuries is reflected principally in surviving mosaics and sarcophagi; the Early Christian basilicas have largely vanished. From the early 6th century the Visigoths dominated Spain; their few surviving churches display primitive, vigorous stonework and carved capitals and lintels.

The Middle Ages

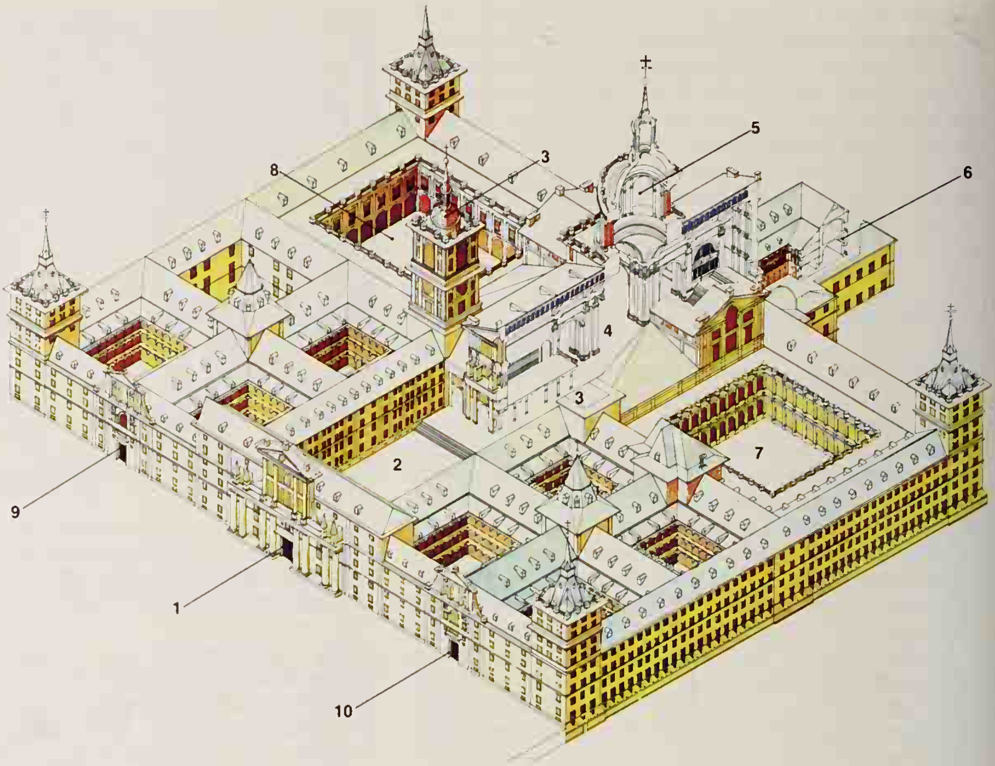
Moorish Art. After overrunning Spain in the first half of the 8th century, the Moors established a brilliant court at Córdoba, from which they ruled an ever-shrinking portion of the country until their expulsion (1492) from Granada. Moorish rule in Spain may be divided into three periods: that of the Arab emirate and caliphate (759–1031), that of the Almoravids and Almohads (1086–1212), and that of the Nasrid dynasty in the south (1230–1492). Each period produced one outstanding monument. The Cathedral of Córdoba (786–999), one of the world's greatest mosques, is highlighted by a staggering array of double-tiered, polylobed arches. The minaret of Seville, or the Giralda (completed 1198; now the cathedral bell tower), embodies the strength of the ascetic Almohads in its combination of monumental proportions and restrained decoration. The last phase of Moorish rule left the most lavishly decorated of Moorish palaces, the ALHAMBRA (1238–1391) of Granada.



The massive Great Mosque (now Cathedral) of Córdoba was begun in the 8th century by Emir Abd al-Rahman I and enlarged by subsequent Muslim rulers. The hundreds of columns support double horseshoe arches of alternating brick and stone.

The Christians who lived under or fled the Moors created a unique artistic style, both in architecture and in manuscript illumination, that flourished from the 9th to the early 11th century. In this so-called Mozarabic art, Visigothic or Northern antecedents merged with Moorish and Eastern influences to form a composite style evident in a scattering of isolated, highly individualistic churches with horseshoe arches and a group of colorful, vigorously stylized Beatus manuscripts (commentaries on the Apocalypse) from northern monasteries. As the Christians extended their reconquest, they employed Moorish workers who introduced into Christian architecture Moorish building and decorative techniques and developed a style called Mudejar, which persisted even after the withdrawal of the Moors.

Romanesque Art. Northern Spain embraced ROMANESQUE ART AND ARCHITECTURE. In Catalonia a very early group of Romanesque churches—the largest being Santa Maria in Ripoll (1020–32)—shows Italian Lombard influence; many of these churches were decorated subsequently with imaginatively stylized frescoes and altar frontals. By the late 11th century French Romanesque influences had begun to spread along the pilgrimage road that led to the shrine of Saint James at Santiago de Compostela (begun 1077). The solid walls and dark interiors of the Romanesque suited the Spanish climate and temperament; the style persisted into the 13th cen-



The Escorial, built (1562–92) for King Philip II of Spain, is a huge complex of granite structures in the mountains near Madrid. The grand entrance in the center of the west facade (1) *opens into the Courtyard of the Kings* (2). *Twin towers* (3) *dominate the approach to the austere church, seen here in a cutaway view* (4). *The dome* (5) *of the church soars 98 m (320 ft) above the crossing, beneath which is the octagonal royal mausoleum. Behind the church are the state apartments* (6). *To the south is the Courtyard of the Evangelists* (7); *to the north is the Great Court of the Palace* (8). *Flanking the grand entrance are the College* (9) *and the Monastery of Saint Lawrence* (10).

tury, producing many notable monuments in regional variants.

The Impact of Gothic Art. GOTHIC ART AND ARCHITECTURE came to Spain relatively late and as a borrowed style. From the 13th through the 15th century, however, Gothic formulations developed a typically Spanish aspect in a number of magnificent cathedrals. In the northern capital of Léon the elegant mid-13th-century cathedral represents the purest example of French Gothic in Spain. Also in the French tradition but with later exotic accents are the cathedrals of Burgos and Toledo (completed 1227). Into the 15th century, structures increasingly exhibited variety in forms and a new vigor that reflected the emerging Spanish national spirit. The development of the dwarfed clerestory led to such lofty nave arcades as that of Barcelona Cathedral (begun 1298); audacious engineering resulted in the extraordinary vaulting spans of Gerona Cathedral (before 1312). Seville Cathedral (1402–1506) is one of the largest in Europe.

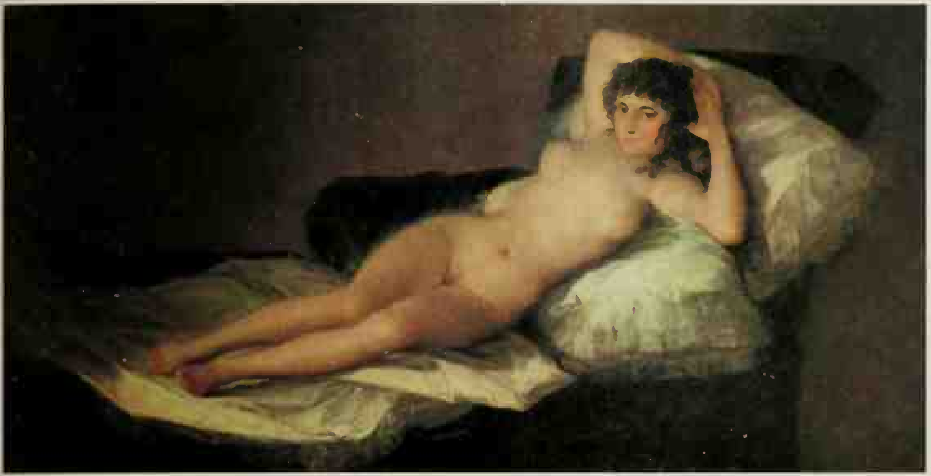
The final phase (*c.*1450–1520) of Spanish Gothic art witnessed an exuberant architectural sculpture characteristic of the Isabelline style, named for Queen Isabella of Castile. Great *retablos*—multipaneled frames containing sculpture in low or high relief—were erected behind the main altars of churches. Similar compositions began to cover the entire central facades of a variety of structures, including the Colegio di San Gregorio (1492) in Vallodolid.

The Flowering of Spanish Art

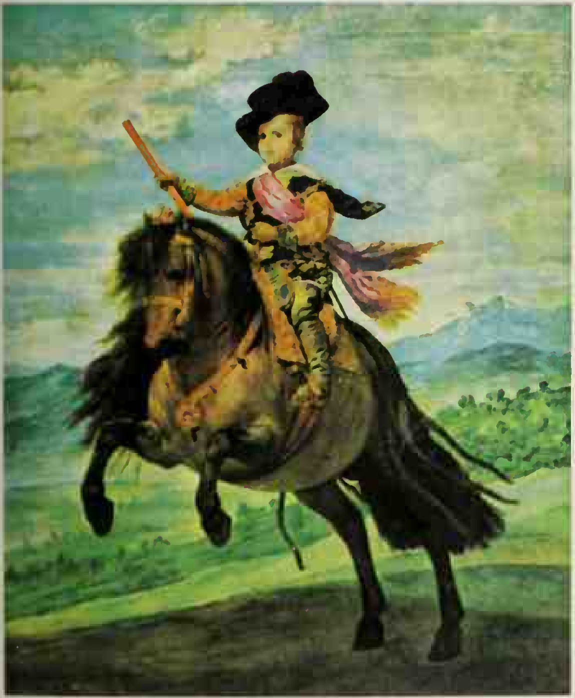
The Renaissance. Throughout much of its history Spanish architecture has favored geometric forms. The Moorish, Mudejar, Isabelline, and Early Renaissance styles added to this basic structural aesthetic a rich embellishment of ornament. During the first half of the 16th century the transition from the Gothic decoration of the Isabelline style to the Italian Renaissance motifs of the so-called Plateresque—from *platero,* "silversmith"—was gradual and often whimsical.

Architecture corresponding structurally to the Italian High Renaissance style—based not merely on surface ornament but on classical proportion and spatial order—came to Spain sporadically, appearing first in Charles V's unfinished palace in Granada (begun *c.*1526). Only after the middle of the 16th century did an austere, typically Spanish Renaissance style develop, epitomized in Philip II's massive monastery-palace, the ESCORIAL (1563–84).

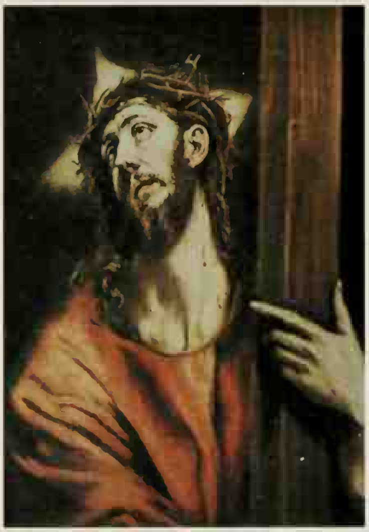
In painting and sculpture a number of important artists emerged during the 15th century. Almost all display a distinctly Spanish stamp of realism and expressive intensity. In Catalonia, a vigorous school of painting culminated in the dark, brooding *Pietá* (1490; Barcelona Cathedral) of Bartolomé Bermejo (fl. 1474–95). The early-16th-century sculpture and architecture of Diego de SILOE show a graceful Renaissance style, whereas the sweeping



The Nude Maja *(c. 1800), by Francisco de Goya, is considered one of the most frankly pleasing nudes ever painted. The subject is the Duchess of Alba, Goya's close friend and patroness; he also painted her as* The Clothed Maja *in the same pose. (Prado, Madrid.)*



(Left) Prince Baltasar Carlos *(c. 1635) is one of many equestrian portraits of the royal family of Spain by Diego Velázquez, who usually set them in the Sierra de Guadarrama, the royal hunting preserve. (Prado, Madrid.)*



(Right) Christ Carrying the Cross *(1590–95) by El Greco conveys the anguish of Christ's Passion. (Brooklyn Museum, New York.)*

Mannerist carving of Alonso BERRUGUETE foreshadows the drama of El Greco's paintings.

The Baroque—Spain's Golden Age. In the 1570s, with the arrival of the Cretan-born and Venetian-trained painter Domenico Theotocopoulos, called EL GRECO, Spain entered upon a century in which painting led the arts, particularly the works of Francisco de ZURBARÁN, Esteban MURILLO, and Jusepe de RIBERA. The art of Spain's Golden Age reached its height in the baroque paintings of Diego VELÁZQUEZ, who served for many years as court painter to Philip IV.

Seventeenth-century Spanish architecture slowly entered the mainstream of the international baroque. Late in the century a long-dormant taste for elaborate decoration reasserted itself in the works of the CHURRIGUERA family. The ornate form of Churrigueresque appears in José de Churriguera's main altar (1693–96) of San Esteban in Salamanca; a more restrained example occurs in Alberto de Churriguera's Plaza Mayor in Salamanca (begun 1728). Other Spanish architects of the early 18th century manifested delightful imagination in works ranging from the soaring facade (1650–1750) of the Cathedral of Santiago de Compostela to Narciso Tomé's (fl. 1715–42) astonishing Transparente (1721–32) in the Cathedral of Toledo.

The restraining effects of a new wave of classicism gripped all of the Spanish arts in the late 1700s. Only the intensely personal vision of the painter Francisco de GOYA y Lucientes enlivened the arts in this era.

Pablo Picasso developed an entirely new classical style following his first visit to Rome in 1917; Three Women at the Spring *(1921), with its statuesque figures bathed in sunlight, is an example. (Museum of Modern Art, New York City.)*

The Modern Era

The idea that a modern age demanded a new art—the underlying premise of ART NOUVEAU in France and the Modernista movement in Barcelona—fired the imagination of Antonio GAUDÍ, who endowed Barcelona with structures of novel form and fantastic ornament. His most impressive work is the ambitious, still-incomplete sanctuary of the Church of the Sagrada Familia (Holy Family; begun 1882).

Spanish artists played key roles in the revolutionary outburst of modern art that occurred in Paris during the early 20th century. Foremost among them was Pablo PICASSO. Other distinguished Spaniards of the modern era include the cubist painter Juan GRIS, the sculptor Julio González, and two very different surrealists—Joan MIRÓ and Salvador DALÍ. Modern activity is widespread and varied, ranging from social commentary and neorealism to pop art.

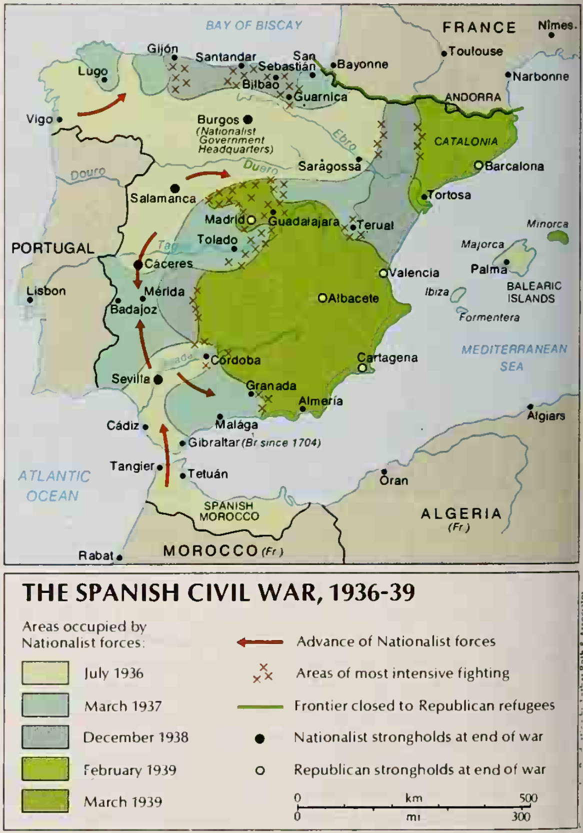
Spanish bayonet see YUCCA

Spanish Civil War The Spanish Civil War began with the military uprising of July 17–18, 1936, and ended with the defeat of the Spanish republic on Mar. 28, 1939. Besides the military, the Nationalist side included conservatives from many parties and extreme rightists such as the CARLISTS and members of the Falange. On the Republican or Loyalist side were republicans, Socialists, Communists, the anarchist CNT (Confederación Nacional del Trabajo), and the revolutionary Marxist POUM (Partido Obrero de Unificación Marxista), the dissident faction of the Spanish Communist party.

The Spanish republic before 1936 was increasingly polarized: from 1931 to 1934 a reformist government alienated landowners, officers, and clergy; from 1934 to 1936 a conservative government repressed workers' rebellions; and in 1936 a leftist Popular Front government threatened to bring about a social revolution.

The war began with a military uprising in Spanish Morocco, led by Gen. Francisco FRANCO. The insurgents then seized control of the agrarian provinces of western Spain, and by the end of July 1936, Spain was split in two. The leftist parties and labor unions succeeded in defending Madrid, but the Loyalists could not push the Nationalists back, and the fighting turned into a stalemate during the winter of 1936–37.

The map shows the areas of intensive fighting and the extension of Nationalist control during the Spanish Civil War. Although the Republicans fought stubbornly, the Italo-German-aided Nationalists effectively ended the war with the capture (March 1939) of Madrid.



During its first months, the war acquired international political and ideological significance. Within less than a year from the conflict's onset, Fascist Italy sent about 70,000 ground troops to aid the Nationalists, and Nazi Germany provided planes, pilots, arms, and technicians. The USSR sent weapons and advisors to the Republicans; the Comintern organized thousands of liberals and leftists from 53 foreign countries—particularly from France—into volunteer International Brigades formed to fight fascism.

The conflict in Spain represented in microcosm the polarization of much of the Western world into extreme left and right camps. Both sides engaged in mass arrests and executions in the name of anticommunism or antifascism, and the Civil War later became known as a dress rehearsal for World War II. Missing, however, were the Western democracies. The United States embargoed arms shipments to both sides, and Britain and France also pursued a policy of nonintervention.

In 1937 the Nationalists scored some gains, taking Málaga in February and the Basque provinces and Asturias by October. Madrid, however, held out. Meanwhile, the Loyalists, unlike their well-disciplined opponents under Franco's dictatorial rule, were beset by internal strife. In May 1937 anarchists and radical Marxists staged an abortive revolution in Barcelona that was opposed by the Socialists and Communists. The Communists, who as the conduit for Soviet aid became increasingly influential on the Loyalist side, led a drive to repress the ultraleftist elements.

Soviet supply shipments declined in 1938, giving the Nationalists a substantial military edge. After an unsuccessful drive into Valencia during the summer, Franco moved on Catalonia in the winter of 1938–39, and Barcelona was captured on Jan. 26, 1939. Isolated in Madrid and Valencia, the Loyalists were sharply divided over whether to continue fighting. When Madrid fell to Franco's forces on Mar. 28, 1939, the Civil War was over.

Spanish colonial architecture see LATIN AMERICAN ART AND ARCHITECTURE

Spanish Guinea see EQUATORIAL GUINEA

Spanish language see ROMANCE LANGUAGES

Spanish literature The first Spanish literature consists of 40 or 50 love lyrics in the Mozarab dialect, known as *jarchas*, that were appended to Hebrew and Arabic poems produced in Moorish Spain during the 11th century. They are considered Europe's earliest Romance-language poetry. Shortly thereafter, the *cantar de gesta*, or epic poem, made its appearance in Spain. The first substantial work in this genre, *The Poem of the Cid* (*c.*1140; Eng. trans., 1959), portrays Spain's national hero, Rodrigo Díaz de Vivar. It relates the unjust exile of EL CID from Castile, his pardon, the marriage and betrayal of his daughters by the arrogant Leonese, and the Cid's revenge.

The Medieval Period

The two principal poetic forms used in medieval Spain were the *mester de juglaría*, or minstrels' mode, for epics, and the *mester de clerecía*, the clerics' mode. The clerics preferred rhymed quatrains to the minstrels' assonated lines. Most of the lyrics produced between the 12th and early 15th centuries were written in Galician-Portuguese and modeled on the poems of the troubadours (see PROVENÇAL LITERATURE).

Alfonso the Wise, king of Castile (r. 1252–84), the first to use Spanish as a cultural language, encouraged translations of the Old Testament and studies in all branches of learning. He wrote important historical and scientific treatises and, in *Las siete partidas* (The Seven Parts, 1256–65), produced the first modern code of laws. His most evocative personal work, *Las cantigas de Santa María* (The Canticles of Saint Mary), is probably the best Marian poetry of the Middle Ages.

The greatest prose writer of the period was Alfonso's nephew, Prince Juan Manuel (1282–1349), who wrote 50 apologues, or allegorical narratives, under the title of *Count Lucanor* (1328–35; Eng. trans., 1868). Appearing 13 years before Boccaccio's DECAMERON (1349–53), the stories concern a young count who constantly seeks advice from his counselor, Patronio. The first full-length Spanish novel, *El caballero Cifar* (*c.*1300–50)—an anonymous work filled with magical and religious elements—was also the first novel of chivalry. In the character of Squire Ribaldo can be seen a prototype of the *pícaro*, or antihero, of later PICARESQUE novels. One of the monuments of Spanish literature, *The Book of Good Love* (1330; Eng. trans., 1972)—known as the "human comedy of the Middle Ages"—was written by the archpriest of Hita, Juan Ruiz (*c.*1283–1350).

The influence of Italian poetry began to make itself felt in the 15th century. Even so, the aristocratic Íñigo López de Mendoza, the marquis of Santillana (1398–1458), won greater fame for his simple *serranillas*—popular songs concerning rustic encounters between refined knights and simple shepherdesses—than for his elegiac, allegorical Italianate verse. Juan de Mena (1411–56), Spain's first professional writer, wrote Latin-influenced poetry and an allegorical masterpiece, *El laberinto de Fortuna* (The Labyrinth of Fortune, 1444). Jorge Manrique (1440–79) created what became the single best-known poem in the Spanish language, *Coplas*, translated by Longfellow in 1833 as *On the Death of His Father.*

The Spanish Renaissance

One of the greatest expressions of Spanish literary genius at the turn of the new century, *The Tragicomedy of Calisto and Melibea* (1499–1502; trans. 1959, and as *The Spanish Bawd*, 1631)—commonly called *Celestina* for its central character—melded medieval and Renaissance motifs. A novel written in dialogue form and divided into 21 acts, it features both humor and tragedy as it contrasts the erotic exaltation of the aristocratic Melibea and noble Calisto with the sordid transactions of the go-between Celestina and her greedy servants. The author, Fernando de Rojas (1465–1541), a Jewish convert to Catholicism, here preaches the theme of moral retribution.

Known as the "faultless" poet of the 16th century, GARCILASO DE LA VEGA fused Italian forms with Spanish tra-

Miguel de Cervantes Saavedra's masterpiece, Don Quixote *(2 vols.; 1605, 1615), a richly imaginative and inventive satire on the chivalric romance, is considered one of the world's greatest novels. Cervantes, also a noted dramatist, created the first Spanish short stories in* Exemplary Novels *(1613), a collection of 12 moral tales.*

dition in his poetry to create a world of the imagination that exalted love and beauty. More exuberant and sonorous in style, Fernando de Herrera (1534–97), the leader of the southern school of poetry, patriotically praised the triumph of Don Juan of Austria over the Turks at Lepanto in his *Canción por la vitoria del Señor Don Juan* (Song in Thanks for the Victory of Don Juan, 1572). Luis de Léon (1527–91), the leader of the northern school of poetry based in Salamanca, and perhaps Spain's finest poet, also wrote prose works of note.

Spanish mystics of the 16th century relied on a highly original use of metaphor and a complicated yet popular language to create their powerful blend of realism and idealism. Saint Teresa of Avila, writing familiarly but passionately of her mystical experiences in her masterpiece, *The Interior Castle* (1588; Eng. trans., 1852, 1972)—also known as *The Mansions of the Soul*—had great literary impact. Saint John of the Cross, Spain's other preeminent mystic, wrote abstract, metaphysical poetry about his attempts at union with God and his struggles to illuminate the "dark night of the soul."

The Novel. In addition to novels of chivalry such as *Amadís of Gaul* (1508; Eng. trans., 1803), based on an early 14th-century romance, Spanish prose forms of the 16th century included pastoral romances, sentimental allegorical novels about love, and Moorish novels filled with impossibly gallant protagonists. The most significant contribution of the period, however, was the anonymous, satirical *Life of Lazarillo de Tormes and of his Fortunes and Adversities* (1554; Eng. trans., 1586), Spain's first important picaresque novel. Later notable examples of the genre include the often moralistic *The Rogue, or the Life of Guzmán de Alfarache* (2 vols., 1599 and 1604; Eng. trans., 1621) by Mateo Alemán and *The History of the Life of the Squire Marcos of Obregón* (1618; Eng. trans., 1816) by Vicente Martínez Espinel.

The culmination of the Spanish novel in the Golden Age was reached in Miguel de Cervantes Saavedra's masterpiece, *El ingenioso hidalgo Don Quijote de la Mancha* (2 vols.; 1605, 1615). More than a parody of the novel of chivalry, Don Quixote (first translated into English, 1612–20) combines the real and the ideal with a quest for truth and the meaning of good and evil. Possibly Spain's greatest literary figure, Cervantes also wrote a pastoral novel (1585), dramas, one-act farces, and 12 *Exemplary Novels* (1613; Eng. trans., 1640), which were prototypes of the Spanish short story.

The Drama. Spanish dramatists of the late 16th century were important for developing the themes and dramatic techniques that a theater going beyond the *autos sacramentales*—or religiously inspired one-act plays performed at Corpus Christi—would need. Among the leading figures are Juan del Encina, known as the father of Spanish drama; Bartolomé de Torres Naharro (1485–1524), who elaborated the rules governing dramatic composition and who brought a new realism to the stage; Juan de la Cueva, the first to use national themes and to mix tragedy and comedy; and Lope de Rueda (*c.*1505–65), the inventor of the *paso*, or brief comic interlude.

Literature of the Golden Age

The four greatest figures of Spanish 17th-century theater are undoubtedly Lope de Vega, Tirso de Molina, Juan Ruiz de Alarcón y Mendoza, and Pedro Calderón de la Barca. Lope, a lyrical genius who also wrote didactic poetry, novels, and short stories, virtually revolutionized theatrical practice with the 1,500 or so plays attributed to him. One of Lope's disciples, Guillén de Castro y Bellvís (1569–1631), is notable as the author of *Las mocedades del Cid* (The Youth of the Cid, 1618), the first drama about Spain's national hero and the inspiration for Pierre Corneille's great tragedy on the same subject (1636). Another of his disciples, Tirso, in the theologically loaded *The Trickster of Seville* (1630; Eng. trans., 1959), presented the first Don Juan. Ruiz de Alarcón keenly observed social vices in his stylized comedies of manners. Calderón's beautiful, allegorical, religious, and philosophical dramas show the work of a careful artist, in contrast to that of the spontaneous Lope. In his rustic masterpiece, *The Mayor of Zalamea* (1643; Eng. trans., 1959), Calderón stresses the honor code, whereas in his ornamented *Life Is a Dream* (1635; Eng. trans., 1968)

Pedro Calderón de la Barca was the last great dramatist of Spain's Golden Age of literature. Calderón's autos sacramentales, *produced in connection with the annual celebration of the feast of Corpus Christi, remain his most acclaimed works, although his* comedias *and history plays are also highly regarded.*

he meditates on free will and human destiny.

In the 17th century, baroque literary forms involved the artificial exaggeration of language and abstract thought. The most famous exponent of the distortion of language for beauty's sake, Luis de GÓNGORA Y ARGOTE—who gave his name to the style known as Gongorism—is primarily known for his highly ornate, pastoral poetic vision, *Solitudes* (1613; Eng. trans., 1921). Francisco Gómez de Quevedo y Villegas (1580–1645) wrote ascetic, philosophical, moral, and satirical works in which he exposed the decadence of his country. Baltasar Gracián y Morales (1601–58), for his part, in his allegorical novel *The Critick* (1651–57; Eng. trans., 1681), contrasts natural and instinctive man with civilized and cultured man.

In reaction against the previous century, 18th-century Spanish neoclassicists turned to French and Italian models. Among the few who stood out were Ramón de la Cruz (1731–94), the author of colorful and popular one-act farces; Leandro Fernández de Moratín (1760–1828), who wrote modern thesis plays; and the essayist Benito Jerónimo Feijóo y Montenegro (1676–1764), who brought European culture to Spain.

Romanticism and Realism

Representing romanticism, Ángel de Saavedra (1791–1865), the duke of Rivas, published important narrative poetry and ballads and, with *Don Álvaro* (1835), produced the most exaggerated romantic drama of the century, on which Verdi based his opera *La forza del destino.* Fusing all poetic tendencies in his experimental verse forms, José de Espronceda (1808–42) wrote of happiness as an illusion for which only death provides a solution. José ZORRILLA Y MORAL more affirmatively represented the spirit of Spanish romanticism in his poetry and plays, the most famous of which is *Don Juan Tenorio* (1844; Eng. trans., 1846). Ramón de Campoamor (1817–1901) wrote short, ironic poems exemplifying eternal truths. Gustavo Adolfo Bécquer (1836–70), the greatest lyric poet of the 19th century, composed suggestive, musical verse to express the impalpable quality of frustrated love.

Turning away from the picaresque and allegorical, Spanish novelists embraced realism to express their social views. Cecilia Böhl von Faber, who adopted the pen name Fernán Caballero (1796–1877), published the first well-known regional novel, *The Sea-Gull* (1849; Eng. trans., 1867), and in so doing transferred the essayistic mode known as *costumbrismo* to fiction. The best-known realistic novels, however, were concentrated in the last quarter of the 19th century: *The Three-Cornered Hat* (1874; Eng. trans., 1918, 1935), by Pedro Antonio de ALARCÓN; *Pepita Jiménez* (1874; Eng. trans., 1891), by the ironic and urbane Juan Valera y Alcalá Galiano (1824–1905); and *Peñas arriba* (Up the Mountain, 1894), which praised the virtues of tradition and country life, by José Mariá de Pereda (1833–1906). Benito Pérez Galdós (1843–1920), wrote almost 80 novels dealing with every aspect of Spanish history and society.

Toward the end of the century realism ceded to naturalism in the novels of Leopoldo Alas (1852–1901; better known as Clarín, and Vicente Blasco Ibáñez (1867–1928). Clarín, in *La regenta* (The Judge's Wife, 1884–85), examined the sexual, political, and religious mores of a provincial town and, with his protagonist, Ana Ozores, created one of the great feminine figures of Spanish literature. Of the numerous novels by Blasco Ibáñez, *The Four Horsemen of the Apocalypse* (1916; Eng. trans., 1918), dealing with the pain and violence of World War I, became best known internationally.

The Twentieth Century

The "Generation of '98" demonstrated a love of countryside, nostalgia for past virtues, and passionate interest in the debate over the modernization of Spain. Miguel de UNAMUNO, the most cultured member of the group, tried his hand at all genres. His long poem, *The Christ of Velázquez* (1920; Eng. trans., 1951), and his best-known essay, *The Tragic Sense of Life* (1912; Eng. trans., 1921), as well as his dramas and novels, all reflect the spiritual anguish of modern individuals confronted by their mortality and the failure to reconcile reason with natural human needs. José Martínez Ruiz (1874–1967; also known as Azorín) evoked the timelessness of the Castilian countryside in his descriptive essays. Even more influential abroad than in his homeland, José ORTEGA Y GASSET brought erudition to his discussions of the human condition, art, and the shape of the future in long philosophical essays such as *The Revolt of the Masses* (1930; Eng. trans., 1932) and *The Dehumanization of Art* (1925; Eng. trans., 1948).

Modernism, a literary renovation of form, promoted an evasive aestheticism, but 20th-century poets soon found their own styles. Antonio Machado (1875–1939) represents the eternal verities of the Castilian landscape in his *Campos de Castila* (1912). Juan Ramón JIMÉNEZ stressed beauty and pantheism in his delicate, abstract poems, which in 1956 won him the Nobel Prize. León Felipe Camino y Galicia (1884–1968) employed epic and biblical tones to convey the tragedy of modern humanity and of the Spanish Civil War.

A leader of the Generation of 1927, Federico GARCÍA

Federico Garcia Lorca was one of the most compelling figures of 20th-century Spanish literature. A superb lyric poet and a gifted dramatist, Garcia Lorca evoked the beauty and violence of Spain in his work. Among his most acclaimed verse works are Gypsy Ballads *(1928) and* Lament for Ignacio Sánchez Mejías *(1935).*

LORCA combined popular poetry with odd sensory combinations and magic metaphors in his celebrated *Gypsy Ballads* (1928; Eng. trans., 1953). A surrealist poet, Vicente ALEIXANDRE concentrated in his early poetry on death and erotic fusion with the cosmos; later he discovers man as a social being. In 1977 he won the Nobel Prize for literature. Rafael ALBERTI, in exile in Argentina from the Spanish Civil War to 1977, seeks values in an absurd, disintegrating world.

In the 20th century Jacinto Benavente y Martínez (1866–1954) freed Spanish drama from the melodramatic dictates of José Echegaray y Eizaguirre (1852–1916), subtly satirizing Spanish society in such dramas as *The Bonds of Interest* (1907; Eng. trans., 1936). The author of 172 plays, he was honored by the Nobel Prize (1922) midway in his career. Ramón del Valle Inclán (1866–1936), author of lyrical erotic novels, in the 1920s developed the *esperpento*, an expressionistic type of theater that grotesquely distorted reality through the deformation of language and the use of puppetlike characters. Alejandro Casona (1903–65) wrote about the need to face life bravely in his special fusion of fantasy and realism. Antonio Buero Vallejo (b. 1916), in fantastic, philosophical, psychological, and historical tragedies of hope, dramatizes human dignity and responsibility. In a more pessimistic vein, Alfonso Sastre (b. 1926), deals with the social and existential dilemmas of people tortured and trapped by their own weaknesses.

The Spanish Civil War has long been an obsession of Spanish writers. José María Gironella's *The Cypresses Believe in God* (1953; Eng. trans., 1955) is an attempt to explain the ideologies involved. Ana María Matute's *In This Land* (1955) is an expurgated version of an earlier, censored work and a precursor of her fine war novel, *The Lost Children* (1958; Eng. trans., 1965).

The death (1975) of dictator Francisco Franco ended a censorship characterized as much by puritanism as by political restrictions. During the dictatorship many prominent writers went into exile, among them the playwright Fernando ARRABAL and the novelists Ramón Sender (1901–82) and Ramón Pérez de Ayala (1880–1962). Both novelists express an ultimate faith in humanity, but Camilo José CELA's brutal and violent *The Family of Pascual Duarte* (1942; Eng. trans., 1953) typifies a popular literary style called *tremendismo*. Less obvious but equally pessimistic is the work of another exile, Juan GOYTISOLO, and of the major novelist Miguel Delibes.

See also: CATALAN LITERATURE; LATIN AMERICAN LITERATURE.

Spanish missions The history of Spain's missions in the American South and Southwest reveals much about Spain's strategy, contributions, and failures in these regions. The expeditions of Francisco Vázquez de CORONADO (1540–42) and Juan de OÑATE (1598) convinced Spanish authorities that no wealthy Indian empires like that of the Aztecs were to be found north of Mexico. Consequently the Spanish came to view the northern frontier of their empire as a defensive barrier and as a place where pagan souls might be saved. In what are now the states of Florida, Texas, New Mexico, Arizona, and California, missions were founded to propagate Roman Catholicism. To protect these missions as well as the mines and ranches of Mexico from attack

Two of the finest Spanish missions in the American Southwest are the mission of San Xavier del Bac (1700; rebuilt 1783–97) (right) *near Tucson, Ariz., and the mission of San José y San Miguel de Aguayo (1720–31; restored 1933)* (below) *in San Antonio, Tex. Used for religious education and training in European agriculture, the mission compounds included such structures as the chapel, friars' quarters, storehouses, and work areas.*

from the north, the Spanish established presidios—fortified garrisons of troops.

Franciscan priests founded a series of missions in Florida after 1573, mainly along the Atlantic and Gulf coasts. The first missions in New Mexico were established by friars accompanying the Oñate expedition of 1598; during the next 100 years Franciscan priests founded more than 40 additional missions, most of them along the Rio Grande. Especially influential was Father Alonso de Benavides, who directed the founding of 10 missions between 1625 and 1629. By 1680 missions had been established among most of the New Mexican Indians.

A French landing led by Robert Cavelier, sieur de LA SALLE, on the Texas coast in 1684 spurred the Spanish to build missions in that area. San Antonio became the home of several missions, including San Antonio de Valero (the ALAMO).

Between 1687 and 1711 the missionary and explorer Father Eusebio KINO established many missions in northern Mexico and Baja California as well as some in southern Arizona, the most notable of which was Mission San Xavier del Bac. When the Spanish began to settle in California, Father Junípero SERRA accompanied the expedition of José de Gálvez in 1769 and founded the Mission San Diego de Alcalá at San Diego, the first of 21 Franciscan missions in California. The last was San Francisco Solano (1823), located in the Sonoma Valley.

In seeking to introduce both Catholicism and European methods of agriculture, the missions encouraged the Indians to establish their settlements close by, where the priests could give them religious instruction and supervise their labor. Unfortunately this arrangement exposed the Indians to the Europeans' diseases, against which they had little immunity. An epidemic in New Mexico, for instance, killed 3,000 Indians in 1640. Critics charged also that the mission system destroyed much of the Indians' native culture and turned them into an exploited and degraded labor force. Indeed, there were sporadic rebellions; the most spectacular was led by an Indian named POPÉ in 1680; almost 400 Spaniards were killed, and the rest were temporarily driven from Santa Fe and northern New Mexico.

In design the missions reflected Gothic, Moorish, and Romanesque architectural styles—the various cultural influences brought by the Spanish. Paintings on interior walls sometimes depicted the Southwestern landscape and the artistic traditions of the Indians. Among the best surviving examples are Missions San José y San Miguel de Aguayo in San Antonio, Tex.; San Juan Capistrano, in the California town of the same name; and San Xavier del Bac near Tucson, Ariz.

See also: LATIN AMERICAN ART AND ARCHITECTURE.

Spanish moss

Spanish moss Spanish moss, or graybeard, *Tillandsia usneoides,* is an epiphytic herb belonging to the pineapple family, Bromeliaceae. This moss, whose individual stems bear threadlike leaves and green or blue inconspicuous flowers, hangs from tree branches in strands up to 6.1 m (20 ft) long. It ranges from the southeastern United States to Argentina. Besides being considered a graceful ornamental plant, Spanish moss is used as packing material and as upholstery stuffing.

Spanish music

Spanish music Spain comprises many regions with their own historical and cultural characteristics, including a variety of languages (Castilian, Catalan, Basque, Galician), and this regional diversity is strongly reflected in its music. Also an important influence on the music of Spain was the invasion by the Arabs and Moors and the long occupation that followed (711–1492). It was particularly significant in the southern region of Andalusia and is reflected in the style called *cante jondo* ("deep song"), with its florid melodies and exotic scales. Moorish musicians were also active at the court of Alfonso the Wise (1221–84), who ruled the united kingdom of Castile and Léon and who compiled a famous collection of religious songs with instrumental accompaniment in praise of the Virgin Mary, the *Cantigas de Santa María.*

By 1492, Spain had achieved some degree of political unity under the rule of Ferdinand and Isabella, and music and the arts flourished. Secular vocal music began with ballads that recounted heroic exploits, tragic events, and tales of love. These ballads were part of the folklore of the common people, but they also appeared in arrangements by court composers for three or four voices, or for solo voice with guitar or *vihuela* (a combination of lute and guitar).

The ballad was called *romance* in Spanish, and its rustic counterpart was the *villancico,* originally a song of the peasants or villagers. The *villancico* became popular during the Renaissance, in the form of part-songs arranged by the leading composers of that period, such as Juan del ENCINA. The most important collection of *villancicos* is the so-called *Cancionero de palacio* (Palace Songbook), containing nearly 500 songs.

During the 16th and 17th centuries many composers published collections of instrumental and vocal music, at first for the *vihuela* and later the guitar. Among the best-known were Luis de Milán's *El maestro* (The Master; 1535), Enríquez de Valderábano's *Silva de sirenas* (Songs of the Sirens; 1547), Miguel de Fuenllana's *Orphénica lyra* (Orpheus' Lyre; 1554), and Esteban Daza's *El parnaso* (The Poetry Collection; 1576). These compositions were all written for the six-string guitar, which in the 17th century was replaced by the guitar with five strings, known as the Spanish guitar—the characteristic instrument of Spain.

Spain could boast of having some of the greatest composers of church music in this period, notably Cristóbal de Morales (*c.*1500–53), Francisco Guerrero (1527–99), and above all Tomás Luis de VICTORIA, for his great *Requiem Mass* (1605).

The Spanish lyric drama began its development in the 17th century with an opera titled *La selva sin amor* (The Loveless Forest). Its text was written by Lope de Vega, but the composer is unknown. Juan Hidalgo (*c.*1600–85) wrote the music for several opera librettos by Calderón de la Barca. The most popular form of musical theater in

Spain, however, was the ZARZUELA, which combined singing and spoken dialogue and generally had a comic or entertaining plot. It originated in the 18th century but had its greatest vogue during the 19th. The master of this form was Francisco Asenjo Barbieri (1823–94), famous for his *Pan y toros* (Bread and Bulls, 1864) and *El barberillo de Lavapiés* (The Barber of Lavapiés, 1874).

As the 20th century approached, Spain produced three of the best-known composers of modern times: Isaac Albéniz, Enrique GRANADOS, and Manuel de FALLA. All were influenced by the scholar Felipe Pedrell (1841–1922), who advocated the creation of a Spanish "national" expression based on Spain's rich heritage of folk music. Albéniz's greatest contribution was *Iberia* (1909), a suite of 12 pieces for piano brilliantly evoking the regions and cities of Spain. Granados did the same, in a more lyrical manner, with his *Spanish Dances* and the suite *Goyescas* (1912–14), both works written for piano. The themes and scenes of the latter, based on tapestry designs by the painter Goya, were also used by Granados in an opera of the same title, produced in 1916.

Manuel de Falla achieved worldwide fame with his ballets *El amor brujo* (Love the Sorcerer, 1915) and *The Three Cornered Hat* (1919), both imbued with the folklore and dances of Spain. He evoked the legendary spirit of Andalusia in *Nights in the Gardens of Spain* (1909–15), composed for piano and orchestra.

The most successful composers of the generation born around the turn of the century include Joaquin Rodrigo, whose *Concierto de Aranjuez* (1939) is the most widely played of all guitar concertos; Federico Mompou and Rodolfo Halffter, who continued mining the resources of Spanish folk music for their themes; and Joaquin Homs, Spain's first serialist composer. Cristobal Halffter, nephew of Rodolfo, and Luis de Pablo are representative of Spain's contemporary composers, whose music—while still Spanish in its vitality—has moved closer to the modern European mainstream.

Spanish Sahara see WESTERN SAHARA

Spanish Succession, War of the The War of the Spanish Succession (1701–14)—the last of the wars of French King LOUIS XIV—was fought over the vast Spanish Empire, which had been left without an uncontested heir in 1700, when the last Spanish Habsburg king, CHARLES II, died childless. Hoping to preserve the European balance of power, Louis and Britain's King WILLIAM III had drawn up treaties (1698, 1700) dividing the inheritance of the sickly Charles between the leading claimants, the French Bourbons and the Austrian Habsburgs. However, the dying king bequeathed all his territories to Philippe, duc d'Anjou, grandson of Louis XIV; if Philippe declined the inheritance, it would go to the Austrian archduke Charles (later Emperor CHARLES VI), second son of Holy Roman Emperor LEOPOLD I.

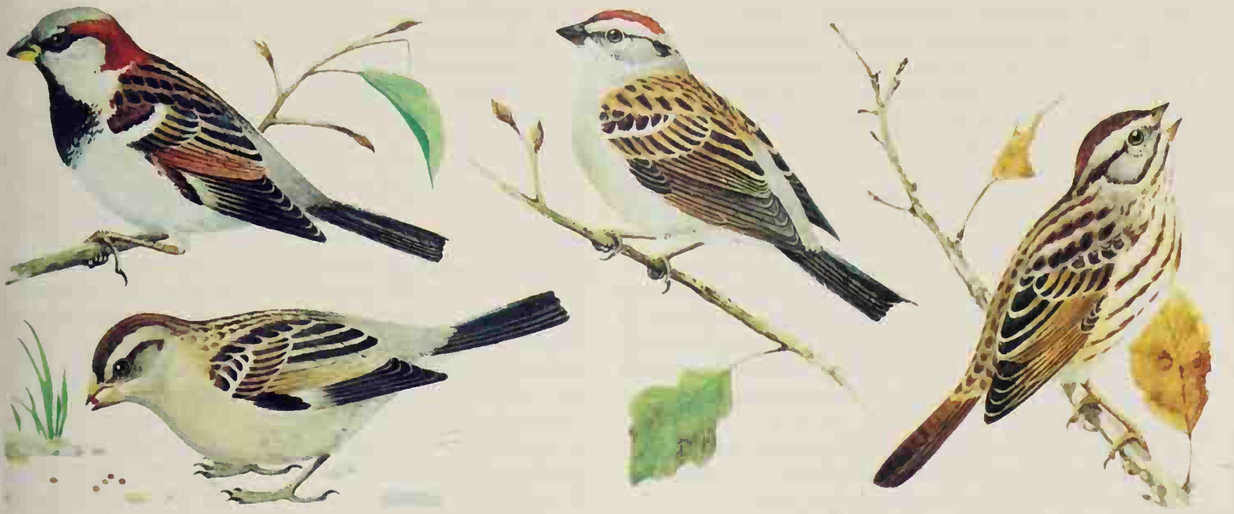
Louis accepted the inheritance for his grandson, who became PHILIP V of Spain, breaking the partition agreement. By subsequently coordinating the military, commercial, and political policies of Spain and France, Louis upset the European power balance. As a result an anti-French alliance was formed. Ultimately, France, Spain, and Bavaria faced a Grand Alliance of the Austrian Habsburgs, most German princes, the United Provinces, Britain, and, after 1703, former French allies Portugal and Savoy.

French victories by the duc de VILLARS in southwest Germany at Friedlingen (1702) and Höchstädt (1703) were offset by Britain's seizure of Gibraltar and by the allied conquest of Bavaria following the brilliant victory (1704) at Blenheim by the duke of MARLBOROUGH and the Austrian commander EUGENE OF SAVOY. France lost the Spanish Netherlands through Marlborough's decisive maneuvering (1706) at Ramillies, although the transfer of the French commander, the duc de VENDÔME, from Italy stopped the British advance short of French soil. Meanwhile, Vendôme's successors lost Turin and all of Italy to Eugene, and Vendôme's mismanagement (1708) of the Battle of Oudenarde left France open to northern invasion. Franco-Spanish success was limited to Spain, where the duke of BERWICK saved Philip V's cause by routing (1707) the allied forces at Almanza. Villars's last-ditch stand (1709) against Marlborough at Malplaquet, although a French defeat, crippled the allies, who suffered 20,000 casualties, whereas the French lost only 11,000. Vendôme's victory (1710) at Villaviciosa demonstrated that Philip V could not be dislodged by military force.

Political events broke the military impasse. In Britain, Marlborough's Whig party was replaced by the propeace Tories. The Dutch ceased hostilities with British assurance of a Dutch-controlled "barrier" of fortresses against France. The deaths of all but two direct descendants of Louis XIV (Philip V of Spain and the future LOUIS XV of France) and of Emperor Leopold and his first son (leaving Emperor Charles VI as sole Austrian Habsburg) forced a compromise settlement of the Spanish succession.

The Peace of Utrecht (1713–14) awarded Spain and its colonies to Bourbon Philip V, keeping France separate but without significant territorial losses. Britain emerged as the great colonial, commercial, and naval power in the world, gaining Gibraltar, Minorca, Hudson Bay, Nova Scotia, Newfoundland, Saint Kitt's, and the sole right to the slave trade with Spain's American colonies. Austria acquired the Spanish Netherlands, Naples, Milan, and Sardinia; the declining United Provinces gained their promised barrier; and Savoy received Sicily. This new balance of power remained until the War of the Austrian Succession (1740–48).

Spark, Muriel Proficient in many genres, the English writer Muriel Sarah Spark, b. Feb. 1, 1918, is best known for her novel *The Prime of Miss Jean Brodie* (1961; play, 1964; film, 1969), which tells the story of an Edinburgh schoolteacher whose penchant for self-dramatization leads to disaster. Although Spark's fiction seems witty and detached, her Catholicism imparts depth and occasional horror to her satires of human folly and sin. Other novels include *Memento Mori* (1959; play, 1964), *Girls*



The male house sparrow (top left) *has a black throat; the female* (bottom) *is brown and gray. Both the male and female chipping sparrow* (center), *of the New World, are similarly colored, as are the male and female song sparrow* (right).

of Slender Means (1963), *The Mandelbaum Gate* (1965), *Not to Disturb* (1971), *Territorial Rights* (1979), *Loitering with Intent* (1982), and *A Far Cry from Kensington* (1988). Spark has also written poetry, plays, biography, and criticism. A collection of short stories was published in 1985.

spark chamber The spark chamber is one of several experimental devices used by physicists to observe the tracks of high-energy charged particles produced in an accelerator. It is distinguished from a CLOUD CHAMBER by its geometry. In its most common form the spark chamber consists of an array of parallel thin metal plates spaced about 10 mm (0.375 in) apart, like the plates of a capacitor, in an atmosphere of helium and argon. The plates are usually made of aluminum foil 0.025–0.050 mm (0.001–0.002 in) thick. For high-energy gamma rays, lead may be used. When a high-voltage pulse is applied across the plates in step with the accelerator pulse, a spark discharge is produced that follows the paths of the ionized particles. To record the events, stereo cameras are used with lenses that "see" into the narrow gaps. Any number of tracks can be seen simultaneously when observing complex events. Data may be read out in digitized form by observing the x,y coordinates of discrete points on the track.

The intrinsic accuracy of track location in the spark chamber approaches that of a BUBBLE CHAMBER. If the initiating pulse is made short and intense, a streamer discharge grows parallel to the plates and, when viewed from the end, appears as bright dots. When strong magnetic fields are applied, the tracks become curved, and magnetic moments or spin characteristics of charged particles can be determined.

sparrow Sparrows are perching birds that are typically 8 to 24 cm (3 to 9.4 in) long, are generally dull colored—brown, gray, white, or pale yellow—and have cone-shaped bills. Although omnivorous, they eat mostly seeds and feed on or near the ground.

Old and New World sparrows are not considered to be closely related taxonomically; the former belong to the family of Old World sparrow-weavers, Ploceidae, and the latter to either the bunting family, Emberizidae, or the finch family, Fringillidae, depending on the classification used.

The sparrow-weavers, native to Eurasia and Africa, include about 35 species, the most widely familiar being the house sparrow, *Passer domesticus.* This species commonly lives close to human habitats. Originally restricted to Eurasia, house sparrows were introduced after 1850 into parts of North America, South America, southern Africa, Australia, New Zealand, and Hawaii. Sparrow-weavers generally build domed nests. Both sexes care for the eggs and later the young.

Many of the more than 50 New World species occur in North America. These sparrows often seek food by scratching away the ground litter with both feet simultaneously during a backward jump. They generally build cup-shaped nests. The song sparrow, *Melospiza melodia,* is one of the most widely known of the North American sparrows.

Sparta One of the two greatest city-states of ancient Greece, Dorian Sparta grew out of four villages settled in and after the 11th century BC. The eventual fusion of these separate villages into a *polis,* or city-state, may explain Sparta's double kingship. By the 8th century the Spartans had conquered all of Laconia, the lower southeastern quarter of the Peloponnesus. Many of the conquered pre-Dorians became helots, or serfs; other neighboring groups in Laconia were granted the semiautonomous status of *perioikoi*, but they were required to serve in the Spartan army. The Spartans acquired the western portion of the lower Peloponnesus by conquering Messenia in the First Messenian War (late 8th century). The Messenians, who were also Dorians, rebelled and were suppressed in the Second Messenian War (mid-7th century).

By at least 600 BC, Sparta had transformed itself into a collectivist warrior society. Seven-year-old boys of the ruling class were removed from their families to be trained for war. Educated by the state, the young grew up in barracks, where they learned discipline and austerity. Spartans became the best warriors in Greece, and the word *Spartan* has since become a byword for endurance and rugged simplicity.

By the mid-6th century Sparta had taken possession of Argive territory along the southeastern Peloponnesian coast, in a battle for supremacy that soon left ARGOS a second-class power. By the end of the century Sparta headed a confederation of all major Peloponnesian cities except Argos—the Peloponnesian League, which in 480–479 became the bulwark of the Greek defense against Persia in the PERSIAN WARS. Athens, which headed a similar alliance of Ionian states, the DELIAN LEAGUE, arose to challenge Sparta. Spartan supremacy was also threatened in 464 by a revolt of helots and *perioikoi*, the Third Messenian War, which was suppressed with difficulty. After an initial indecisive confrontation (446–445) with Athens, the PELOPONNESIAN WAR broke out in 431; it ended in 404 with Sparta's conquest of Athens, after which Sparta resumed leadership of all Greece.

Spartan predominance did not last. The campaign of King AGESILAUS II against the Persians in Anatolia was disappointing, and he was recalled when the Corinthian War broke out in 395. Sparta retained control of Greece in 386 with Persian assistance, but, in 371, Sparta's army and reputation were shattered at Leuctra by THEBES, and Messenia was liberated shortly thereafter. Weakened and suffering from a decline in manpower, the Spartans were helpless before PHILIP II of Macedonia.

In the 3d century they were confronted by the superior power of the Achaean League. Agis IV (r. 244–241) tried to revitalize Sparta in 242 but was killed in the attempt. CLEOMENES III instituted several reforms, overthrowing the main governmental body, the EPHORS, and widely extending citizenship. He fell from power in 222, defeated by the Achaean League and the Macedonians at Sellasia.

After 195, Sparta joined the Achaean League, which was destroyed by the Romans in 146. Under the Romans, Sparta enjoyed prosperity and a certain vogue. In AD 395, Goths under Alaric I destroyed Sparta. The sparse ruins of the ancient city-state lie outside the modern Greek city of Spárti.

See also: DORIANS; GREECE, ANCIENT.

Spartacus Spartacus, d. 71 BC, was a gladiator of Thracian origin who led an uprising of Italian fugitive slaves in 73 BC. His force—eventually 90,000 strong—defeated the Romans seven times and advanced through southern Italy, laying waste to the land. The rebellion was crushed when Spartacus was killed in battle against Marcus Licinius CRASSUS at Lucania, and Crassus and POMPEY THE GREAT had 6,000 of the rebel slaves crucified along the road from Capua to Rome. When the fighting ended, 3,000 Roman prisoners were found unharmed in Spartacus's camp.

Spartanburg Spartanburg is a city in the foothills of the Blue Ridge Mountains of northwestern South Carolina. The seat of Spartanburg County, it has a population of 43,467 (1990). Fertile soil and a temperate climate support a basic agricultural economy producing peaches, cotton, and livestock. Diversified industries manufacture machinery, textiles, furniture, and food products. A statue in the town square commemorates the Revolutionary Battle of Cowpens, fought (1781) nearby. Founded in 1785, the city was named for the Spartan Rifles, a local Revolutionary War unit.

Spassky, Boris [spahs'-kee] Boris Vasilyevich Spassky, b. Jan. 30, 1937, became an international Soviet chess grand master and was world champion from 1969 to 1972. He attained grand master standing in 1955, was world junior champion in 1955–57, and became Soviet champion in 1961. In 1965 he won the Candidates' Tournament, earning the right to challenge for the world championship. It was not until 1969, however, that he won the crown. Spassky held the title for three years before losing it to Bobby FISCHER of the United States.

SPCA see SOCIETY FOR THE PREVENTION OF CRUELTY TO ANIMALS

Speaker, Tris Tristram E. Speaker, b. Hubbard, Tex., Apr. 4, 1888, d. Dec. 8, 1958, was an American professional baseball player whose 22-year major-league career was a model of consistent hitting and flawless fielding. Playing for four teams from 1907 to 1928, Speaker compiled a .344 career batting average in addition to establishing several fielding records. He holds the records for double plays (139) and unassisted double plays (4) by an outfielder and had (until surpassed by Willie Mays) the most career putouts by an outfielder. Speaker's hitting prowess was equally impressive: he had more career doubles (793) than any player in history; he led the American League in doubles 8 times; and he ranks fifth in total career hits (3,515). In 1919, while still an active player, Speaker became the manager of the Cleveland Indians. In the course of achieving a 616-520 won-lost record, he led the team to victory in the 1920 World Series. Speaker was elected to the Baseball Hall of Fame in 1937.

spearfish The spearfishes are two species of billfishes in the family Istiophoridae. Certain marlins are usually classified with the spearfishes in the genus *Tetrapturus.* The shortbill spearfish, *T. angustirostris,* is found in the central and western Pacific. The longbill spearfish, *T. pfluegeri,* is a longer-billed species of the Atlantic Ocean. Both spearfishes rarely exceed 1.8 m (6 ft) in length and 27 kg (60 lb) in weight.

spearmint Spearmint is the common name for a perennial herb, *Mentha spicata*, of the family Labiatae. Native to Europe, this garden mint has become naturalized in North America. Spearmint sprigs are used to flavor drinks, such as mint julep; meats, particularly lamb; and, in Moslem countries, teas. Oil from the leaves is used to flavor chewing gums and medicines.

special education Special education provides unconventional instructional services to individuals who would not receive maximum benefit from purely conventional educational practices. Such individuals include those with physical handicaps, sensory disabilities (blindness and deafness), differences in intellectual capacity (giftedness and mental retardation), speech disorders, behavioral disorders (emotional disturbance), and academic LEARNING DISABILITIES. Instructional services include special teaching techniques, materials, equipment, facilities, and adjunctive services.

Special education did not grow extensively until schooling became common. During the late 18th and early 19th centuries special educational procedures for teaching some school skills to sensorially handicapped pupils were devised. For example, deaf individuals were taught the meanings of printed words by repeated simultaneous presentations of a printed word and a picture of what the word represented. Shortly thereafter attempts to educate retarded and disturbed individuals increased in number and success. During the 19th century many severely handicapped children and youth were taught self-help skills. More recently, medical advances, which help keep more exceptional individuals alive, and the enactment and implementation of compulsory education laws, which put or kept in schools students who otherwise would not be there, have led to an increasing need for special-education services.

As well as special equipment, machines, and materials, special adjunctive services are provided to exceptional individuals in addition to regular and special education. These services include speech training for students who have difficulties related to speaking, physical and occupational therapies for students with physical handicaps, counseling for students who manifest behavioral disorders, and vocational training for the mentally retarded.

By far the most common element of special education is the adoption of specialized instructional techniques. Teachers of hearing-impaired individuals often use sign language as a part of their instruction. Programmed-instruction procedures that are designed to present educational content in small, easily acquired steps are often used with exceptional individuals. BEHAVIOR MODIFICATION techniques such as reinforcement and token economies may be adopted to teach students to complete assignments, work more neatly, or not disrupt other students. Techniques that provide experiences with concrete rather than abstract representations of concepts are common in special education.

Most special education takes place in regular public schools, but some is provided in special public or private day or residential schools, public or private hospitals, and, in some cases, the homes of exceptional individuals. Usually it is not necessary to provide an entire program of services that differ from conventional instruction, but only to modify those aspects of the educational program that must be changed in order to meet the unique needs of the exceptional individual. In general, the smaller the degree of deviation from normal, the fewer the special-education services that are required, and the more likely it is that these services will be provided in normal settings.

In general, children with minimal handicaps from low-income families are more likely to be found in special-education programs than are similarly handicapped children from middle- and upper-income families. When children are considered able to benefit from participation with other children, they are usually taught in the normal school program. This concept, called mainstreaming, is widely advocated.

Where the handicaps of students are minor, a special-education teacher works with the regular classroom teacher to develop needed abilities, such as reading skills. For individuals with slightly greater handicaps, special education may be provided in a separate classroom for part of the school day; or, for severe learning and behavioral problems, students may work full time in a special-education room. Here, the number of students per teacher is usually much lower than in ordinary classrooms. In hospitals and homes, instruction may involve only one teacher and one student.

Special education for severely handicapped students is aimed at teaching basic self-help and self-care skills, such as dressing, chewing, and toileting. For other exceptional students, special education may teach skills that will allow them to benefit from otherwise conventional education. For example, blind students who can read braille are able to participate in many regular education programs. Similarly, when physically handicapped persons are not impeded by architectural barriers, such as stairways, many can receive their education in regular schools.

Special education for the gifted attempts to meet their unique needs. It includes activities beyond the regular curriculum, progress through conventional courses at a faster-than-normal pace, and, often, the opportunity to take college-level courses.

Legislative action (the Education of All Handicapped Children's Act of 1975) requires that all exceptional students (excluding the gifted) have available to them a free and appropriate public educational opportunity that takes place in an educational environment as nearly regular as an individual's handicap permits, and that no individuals may be denied services because of their handicaps.

special forces Small military units that can be deployed in a matter of hours and that use unconventional fighting techniques and equipment, special forces in the United States are separate units within each branch of the service. Their prime functions are rapid intervention in small-scale military conflicts, the aborting of terrorist attacks, the rescue of hostages, and counterinsurgency. They are also used to train military elites of friendly nations in guerrilla warfare.

Essentially COMMANDO groups, special forces have been elements of the U.S. military since World War II, when the army's 1st Ranger Battalion, along with British commandos, raided German positions on the French coast. Ranger groups served in the Korean War. A commando group, the U.S. Army Special Force, was established in 1952. Known as the Green Berets, after their distinctive headgear, they were sent to Vietnam in the late 1950s to aid the South Vietnamese in their fight against antigovernment insurgents.

The army's elite shock troops, which now include several additional special-forces groups, are capable of most forms of unconventional warfare. They are trained as counterinsurgents, able to provide covert and overt military aid to governments besieged by civil war, or to anticommunist rebels. They can penetrate enemy territory, cutting lines of communication, blowing up vital installations, and so forth. Many military planners believe that such troops could participate in "low intensity" conflicts, where they would train, and fight alongside, forces sympathetic to U.S. interests.

After the catastrophic attempt (1980) to rescue U.S. hostages held in Iran (see IRANIAN HOSTAGE CRISIS) by the army's Delta Force—a counterterrorist group modeled on Britain's highly effective Special Air Service (SAS)—more and better-equipped special-forces units have been established. The army's helicopter unit Task Force 160 relieves its special forces from dependence on troop transports of other services. The Navy's SEALS (Sea, Air, and Land Soldiers) specialize in underwater demolition and reconnaissance. The Air Force Special Operations Wing provides transport for secret forays into hostile territory. All of these groups operate separately, and often compete with one another for equipment, funds, and assignments.

special-interest groups Special-interest groups—also called pressure groups or lobbies—are collections of individuals who join together to pursue common interests and to influence public policy. Special-interest groups have been part of the American political process since its beginning and have been viewed ambivalently for more than 200 years. As early as 1787, James Madison warned about the "mischiefs of 'factions,' " his term for such groups. Special-interest groups have also been viewed as an integral and beneficial part of the American political process, legitimized in the U.S. Constitution by the 1st Amendment guarantees of freedom of speech and the right to "petition the Government for a redress of grievances." Governmental officials frequently praise the involvement of special-interest groups as a necessary component of governmental decision making, providing important information on public opinion and on the impact of policy proposals.

The Range of Activities. In the United States special-interest groups number in the thousands. Comparable numbers exist in other large industrialized nations. Groups may be classified in a variety of ways. Some of the broader categories are business, banking, labor, education, farm, health, energy, environment, professional associations, foreign political and economic interests, senior citizens, consumers, women, the poor, and religious groups.

Groups may act individually or through broader "umbrella" organizations. Business groups, for example, include individual corporations (Mobil Oil, for example); trade associations (such as the American Petroleum Institute, representing oil producers and refiners, including Mobil); and broader organizations, including the NATIONAL ASSOCIATION OF MANUFACTURERS. Labor groups include individual unions and labor federations.

Various education interest groups represent teachers, students, parents, school administrators, universities, professors, professional schools, vocational and adult educational institutions, and libraries. Farm groups include such associations as the Associated Milk Producers. Broad farm organizations include the AMERICAN FARM BUREAU FEDERATION and the NATIONAL FARMERS UNION.

Environmental groups include the SIERRA CLUB and the Environmental Action Coalition. Ideological groups include AMERICANS FOR DEMOCRATIC ACTION, a liberal group, and MORAL MAJORITY, a conservative group. Public-interest or citizens groups include Public Citizen (one of the Ralph NADER groups), COMMON CAUSE, and the LEAGUE OF WOMEN VOTERS. Consumers are represented by such groups as the Consumers Union and the Consumer Federation of America, and women by the NATIONAL ORGANIZATION FOR WOMEN.

How the Groups Operate. A large number of special-interest groups engage in extensive activity in both national and state capitals and at the local level, attempting to influence government policy decisions. Many groups have permanent Washington offices; some retain law firms or other groups to act as LOBBYISTS. Their goals may range from passing, blocking, or amending legislation to achieving a favorable regulatory ruling, receiving a government contract, or obtaining a favorable presidential decision.

When dealing with the Congress, interest groups focus most of their operations on the committees of the House and Senate, which are the key units for considering legislation. Many groups rely on "grass-roots" activity—generating letters to political leaders from their constituents and sometimes working to defeat a candidate who opposes their position or interests. Occasionally, demonstrations are used in order to demonstrate a group's mass appeal.

Many groups are represented in Washington by former members of the Congress, former congressional or White House staff members, or former Cabinet officers; these people provide both political skills and substantive knowledge of the workings of the government.

Special-Interest Groups in the 1980s. During the late

1970s and 1980s pressure groups took on new importance in U.S. politics. "Single-issue politics," whereby many individuals and groups supported or rejected candidates based solely on their views on particular questions—abortion or gun control, for example—came to the fore and were regarded as increasingly important factors in political contests.

The sources for these developments were many. Campaign financing reforms enacted in the mid-1970s limited direct contributions to candidates and made POLITICAL-ACTION COMMITTEES (PACs) a very effective way to channel political contributions. Some PACs represented corporations, some labor groups, and others industry or trade associations. Many, however, arose over specific issues or had explicitly ideological agendas.

The spread of direct primaries and television-based campaigning, along with the decline of traditional party strength and the passage of reforms that opened congressional behavior to public scrutiny, increased legislators' vulnerability to interest groups able to arouse public opinion.

Special Olympics The Special Olympics is organized athletic competition at the local, national, and international levels for people 8 years of age or older with mental retardation. Since its creation in 1968, using funds from the Joseph P. Kennedy, Jr., Foundation, the Special Olympics has grown to include more than 750,0000 participants in 100 countries. The Special Olympics program offers year-round training and competition and culminates with international games, which are held every 2 years, winter and summer sports alternating. The summer events include aquatics, basketball, bowling, equestrian, gymnastics, roller skating, soccer, softball, track and field, and volleyball. There may also be demonstration events in canoeing, cycling, table tennis, tennis, team handball, and powerlifting. Winter sports include Alpine and cross-country skiing, figure skating, speed skating, floor hockey, and poly hockey. In 1989 the International Winter Special Olympics attracted more than 2,500 athletes. About 6,000 participated in the 1991 summer games.

specific gravity *Specific gravity,* a term being replaced by *relative density,* is the ratio of the DENSITY of a given substance to the density of a standard of reference at standard temperature and pressure. The standard of reference for solids and liquids is the density of water; for gases, the density of air.

specific heat see HEAT CAPACITY

spectroheliograph A spectroheliograph is an instrument for producing monochromatic photographs of the Sun. George Ellery HALE designed the first spectroheliograph in 1891, in which square prisms were rotated in front of a first slit and behind a second. The image of the Sun falls on the first slit and the second isolates the selected wavelength. The monochromatic image of the Sun develops on a plate behind the second slit. Modern instruments use SPECTROSCOPES in place of prisms. Usually, only a segment of the Sun is photographed by a spectroheliograph; a complete picture of the Sun may be made by taking a series of pictures and combining them or by coordinating oscillating slits. Any wavelength may be chosen, but interest centered first on the K line of ionized calcium (393.3 nanometers), and later on the H-alpha line of hydrogen (656.3 nanometers). In this way spectroheliograms were produced that showed the distribution of calcium and helium on the Sun's surface. During solar emissions, images can be taken of the disturbed areas.

spectrophotometer A spectrophotometer is an optical instrument for comparing the composition and intensity of light with light from another source. When a substance is burned in a flame, the light emitted contains wavelengths of light specific for the elements of the substance. A flame spectrophotometer can be used to analyze this light and identify and quantitate the elements. The absorbance spectrophotometer is widely used in all analytical laboratories to identify and quantitate substances in solutions based on the absorbance of light directed through the sample.

See also: ABSORPTION, LIGHT; SPECTROSCOPY.

spectroscope The spectroscope is a visual optical instrument that separates a beam of radiation into its component wavelengths. The early, fundamental spectroscopes of Augustin Fresnel and Joseph Fraunhofer (early 1800s) stemmed from Isaac Newton's experiment of 1669 in which he demonstrated that white light is a mixture of all the colors of the rainbow. Since then the spectroscope has been greatly improved, and it has spawned a score or more of technically related research and analytical instruments, all members of what might be termed a *spectro* family.

Spectro Instruments. The term *scope* in the word *spectroscope* adequately describes an instrument for visually viewing a spectrum; if a meter is added to substitute for a manually performed reading procedure the instrument becomes a spectrometer. If the apparatus includes a recording device the word *spectrograph* is appropriate, although *recording spectrometer* would be equally descriptive. A spectroscope is generally assumed to operate in the range of visible light unless other regions of the electromagnetic spectrum are specified. Specialized spectrometers analyze infrared, ultraviolet, and gamma radiation and magnetic resonance phenomena.

Spectro analyzers measure either the absorption or the emission of certain wavelengths of radiation. When the energy level of a sample must be raised before it can be analyzed, the name of the instrument suggests the activation process—for example, the optical emission spectrometer or the flame photometer.

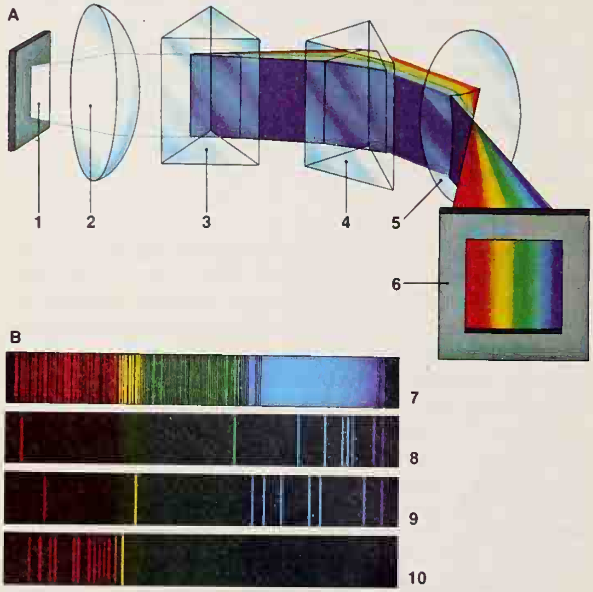
The Spectroscope. The fundamental spectroscope—

which includes both the early instruments and the simpler teaching instruments of the present—is comprised of a slit to admit light, a collimator for rendering the light from the slit parallel before it enters the prism, one or more dispersing prisms, and a telescope for forming images of the slit in the various wavelengths. A camera may be used in place of the telescope eyepiece and the prism replaced with a DIFFRACTION GRATING to improve the optical performance of the instrument.

In 1856, George Bunsen and others shifted the emphasis of the spectroscope from research on the properties of light and the effects of light on various materials to use for chemical analysis. By heating materials in the tip of a Bunsen burner at temperatures of up to nearly 1,800° C, vaporization was achieved, making it possible to determine the light radiation characteristics of the vaporized material and thus to establish spectral lines for the chemical elements.

Automated Spectroscopy. Fully automatic analysis equipment is particularly useful where there are many similar samples to be analyzed, such as samples of steel from large numbers of furnaces or serum from many patients. Instruments have been developed for the quantitative determination of specific components of a process stream, as for example the analysis for a specific gas in mixed-gas stream.

A spectroscope (A) *produces a spectrum by separating the component wavelengths in radiant energy. Light rays emitted by a substance are passed through a narrow slit* (1), *made parallel by a collimating lens* (2), *then refracted by a prism* (3). *The resulting spectrum is enlarged by a second prism* (4), *then focused through a lens* (5) *onto a screen or photographic plate* (6) *to be analyzed. Elements can be identified by their characteristic spectra* (B). *Seen here are the spectra of molecular hydrogen* (7), *atomic hydrogen* (8), *helium* (9), *and neon* (10).



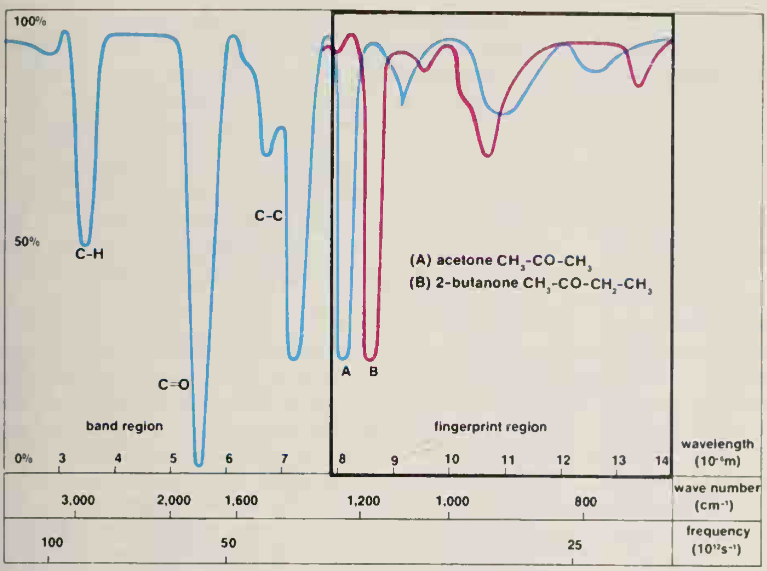
spectroscopy Different materials absorb or emit ELECTROMAGNETIC RADIATION to varying extents, depending on their electronic structure. Therefore studies of the electromagnetic SPECTRUM of a material yield scientific information. Such studies are collectively known as spectroscopy (see SPECTROSCOPE). They are used for research and analysis in many fields, including chemistry, physics, astronomy, biology, and medicine.

Many spectroscopic methods are based upon the exposure of a sample substance to electromagnetic radiation. Measurements are then made of how the intensity of radiation absorbed, emitted, or scattered by the sample changes as a function of the energy, wavelength, or frequency of the radiation. Other important methods are based upon using beams of electrons or other particles to excite a sample to emit radiation, or using radiation to induce a sample to emit electrons. In conjunction with the related techniques of MASS SPECTROMETRY and X-ray or neutron diffraction, spectroscopy has almost completely replaced classical chemical analysis in studies of the structure of materials.

Toward the end of the 19th century, physicists began a systematic investigation of the structure of the ATOM. Atomic spectroscopy was the most important aid to the evolution of modern theories of atomic structure. The ability to explain mathematically an observed spectrum of an atom, or to predict and subsequently discover new spectral lines, was the strongest evidence that the theories used were correct (see HYDROGEN SPECTRUM). Only later were molecular spectra studied.

The development of vibrational infrared (IR) absorption spectroscopy after World War II was a major step in applying molecular spectroscopy to determine molecular structure. The IR spectrum, and the complementary scattering spectrum called the Raman spectrum, provide information about vibrations of atoms with respect to each other, the most important vibrations being the mutual vibrations of two bonded atoms. (Vibrations of larger fragments of a molecule are less important for identifying molecular structures.) In IR spectroscopy the two vibrating atoms are regarded as two point masses connected by a spring (representing the bond between the two atoms). The frequency of the vibration corresponds to the frequency of the absorbed radiation, and it depends on the masses of the atoms and the bond strength. This frequency is characteristic of the two atoms and is practically independent of the rest of the molecule. Many chemical groups can be recognized from a vibrational spectrum, doing away with the need for conducting more complicated and time-consuming qualitative chemical analyses.

The growth of many spectroscopic methods followed the development of new radiation sources, more sensitive equipment for analyzing or detecting radiation, and other such advances. The investigation of small-energy transitions that many molecules undergo in a magnetic field, for example, developed during the 1940s into nuclear magnetic resonance (NMR) spectroscopy. Since the 1960s this technique has replaced IR spectroscopy as the most important analytical method in organic chemis-



Infrared (IR) absorption spectra are used by chemists to identify organic compounds and are obtained by measuring a substance's absorption of IR radiation at different frequencies. The frequencies absorbed are the same as the frequency with which the atoms within the molecules vibrate relative to one another, and depend on the atomic masses and on the atomic-bond strengths. Absorptions of about 3–7 microns (10^{-6} m) are associated with certain functional groups, such as C – H, C = 0, and C – C. The presence of specific absorption peaks can thus be used to indicate the presence of such groups in a molecule. Other vibrational frequencies in the 7- to 14-micron region are characteristic of the entire molecule. This region is called the fingerprint region because it can be used to differentiate between molecules with the same functional groups. Acetone (CH_3COCH_3) and 2-butanone ($CH_3COCH_2CH_3$) are related compounds that have essentially the same spectra in the band region (left). *In the fingerprint region* (right), *the spectra differ enough to allow identification of acetone* (blue) *and of 2-butanone* (red).

try. The understanding of NMR spectra gained by organic chemists and the development of large superconducting magnets and fast data-acquisition computers during the 1970s also led to the application of NMR imaging spectroscopy as a noninvasive method of medical diagnosis (see MAGNETIC RESONANCE IMAGING).

The wide availability of lasers since the 1960s also facilitated the use of Raman spectroscopy, the companion of IR spectroscopy. The development of intense, tunable SYNCHROTRON RADIATION sources during the 1980s further led to the development of many new spectroscopic methods for studying the structures and properties of solids.

A molecule can rotate as well as vibrate. The difference in energy between rotational states is very small, and the absorbed radiation is in the far infrared region or even the microwave region. Instrumentation for microwave spectroscopy is very complicated and unsuitable for routine analyses, and microwave spectra are more difficult to interpret than vibrational spectra. Very precise values of moments of inertia, bond angles, and bond lengths, however, can be derived from microwave spectra of molecules that are not too complicated. Microwave spectra detected by radio telescopes also have been used to identify molecules in interstellar and intergalactic regions of the universe.

Electronic spectroscopy may involve visible, ultraviolet (UV), X-ray, or even IR radiation. The atomic processes that occur in the IR, visible, and UV regions are similar, involving transitions of the electrons that participate in chemical bonding. UV spectra provide less information on structures of compounds than do vibrational and NMR spectra. Thus UV spectroscopy is not a standard technique for structural analysis, but it is widely used in the determination of concentrations of solutions.

X-ray spectroscopy involves electrons bound in atomic cores that are only slightly affected by neighboring atoms. Intense synchrotron X-ray sources must be used to resolve the fine effects of neighbors on the X-ray absorption spectra. Bond distances to neighboring atoms can be derived by interpreting the resulting extended X-ray absorption fine structure (EXAFS) spectra.

spectrum A spectrum, in general, is the dispersion or display of LIGHT, RADIATION, or ENERGY into its components. White light is a continuous spectrum; all wavelengths (or frequencies) of visible light are present. The separation of white light is effected by a PRISM or DIFFRACTION GRATING to create a spectrum of colors; the RAINBOW is a natural example of this spectrum. Some spectra comprise only a few wavelengths, whereas others contain all except a handful that are conspicuously absent. As recorded on spectrograph film, the former appear as bright lines on a dark background and the latter as dark lines on a continuous spectrum.

Atomic Spectra. If a glass tube is filled with some atomic or molecular gas—say, neon—and if a sufficient voltage is applied across it, the gas would glow with a (seemingly) single color. Allowing this light to then pass through a spectrograph (a series of prisms) creates a bright-line spectrum. The light would separate into differently colored light beams moving at different angles, each then falling at a different place on a spectrograph film.

The radiation spectrum emitted from atoms and molecules consists of several discrete sets of frequencies. Between any two neighboring spectral lines there are no other lines from this set. The radiation spectrum of hydrogen is unique to hydrogen; similarly, the spectrum of each atomic and molecular species is unique to that species. Scientists have been able to use this feature of the emitted radiation of the atoms of matter to identify unknown elements of radiating gases, even in distant stars, by comparing the emitted spectrum with the appropriate superposition of spectra of known elements. The explanations for the discreteness, or sharp lines, of radiation spectra is that the energy of the electrons of "excited" atoms also forms a discrete spectrum (see QUANTUM MECHANICS).

The Electromagnetic Spectrum. It was discovered in the 19th and 20th centuries that a wide variety of physical phenomena—light, gamma rays, and so on—were merely separate or overlapping regions of the same spectrum. Thus, all of these phenomena were conceptually unified in terms of one physical explanation—the electromagnetic spectrum (see ELECTROMAGNETIC RADIATION.) The wavelength of electromagnetic radiation is pertinent to the size ranges of matter that absorbs it, so different wavelengths of radiation are useful as experimental tools to probe the properties of matter in different size ranges. For example, gamma rays are absorbed by atomic nuclei, so they are used in the study of nuclear physics; X rays are absorbed by the individual atoms of a gas or a solid, so they are used to study atomic and solid-state phenomena; and wavelengths of the order of 10^{-4} cm (ultraviolet) are appropriate for studying viruses.

speech Human speech makes possible the expression and communication of thoughts, needs, and emotions through vocalization in the form of words. It is a process whose specialized adaptations differentiate it from the mere making of sounds—a capacity humans share with most animals. In addition to the capacity for laryngeal production of sound (which some animals also possess), speech requires a resonance system for modulation and amplification of that sound and an articulation process for the shaping of that sound into the communally established word-symbols of meaning that constitute the language of a given culture. The use of language is made possible by certain cerebral functions: the formation of thoughts; the comprehension, storage, and recall of words; and the selection of words to express the thoughts and the arrangements of these words in a sequence that constitutes (or attempts to constitute) intelligible communication.

Communication exists in all animal species, either in the form of sound utterance or in a large repertory of soundless codes formed and stereotyped by the respective genetic potentials. Some of the higher animal forms possess voices of various types and inflections and may even be trained to imitate the sound of simple words. The vocalizations made, however—for example, by monkeys and chimpanzees—appear to be primarily under the control of centers in the limbic system, or "emotional brain," rather than the cortex. Electrical stimulation of the limbic system can produce all the vocal responses that monkeys are capable of making. Destruction of the cortical speech centers in humans, however, either destroys speech or affects it critically, whereas destruction of similar areas of the cortex in monkeys does not affect their vocalization (see ANIMAL COMMUNICATION). Thus the human brain appears to be uniquely adapted for speech. Only in humans have the centers of speech been transferred from instinctive or reflex centers to the cortex, making possible a highly voluntary control of speech and language.

When and how this transfer occurred and what made it occur are matters of theory. The general consensus, however, is that both speech and language arose more than 1 million years ago, under conditions that have not yet been definitively identified. Whatever its origins, speech is now more than a mode of oral expression and communication. Speech and language together serve to consolidate personal and communal experience; they involve not only physiological mechanisms and their brain control areas but also psychological, cultural, and emotional functions.

Physiology of Speech

The speech process involves the speech centers of the brain, the respiratory center in the brain stem, the respiratory system, the chest cavity, the structures of the larynx, the pharynx, the nose and nasal cavities, and the structures and parts of the mouth and related facial muscles.

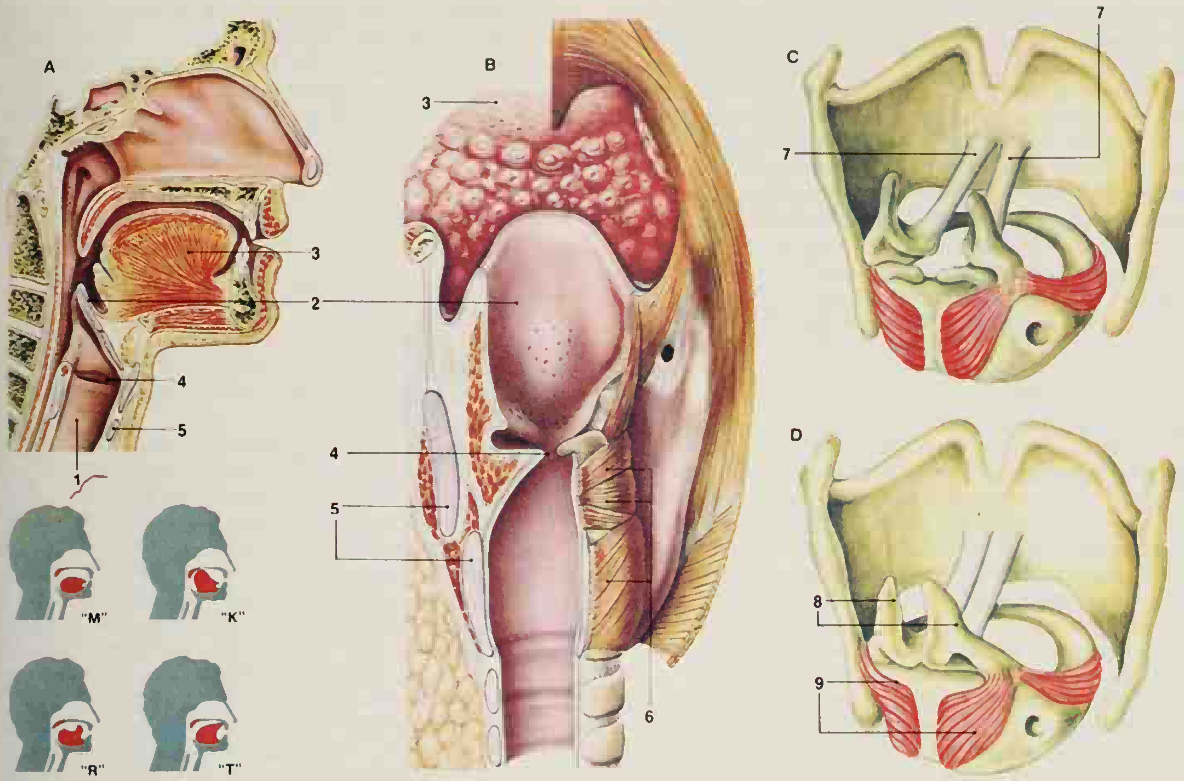
Speech Centers of the Brain. There are three identified speech areas of the brain. The supplementary motor cortex, on the top of the left frontal lobe, involves the process of vocalization. Broca's area, at the back of the left frontal lobe, appears to govern articulation, vocabulary, inflection, and word sequence. Wernicke's area is the posterior part of the left temporal lobe, with parts of the parietal area; it involves the capacity for meaningful speech.

The mechanisms of vocalization perform four major functions: breathing, phonation, resonance, and articulation.

Breathing. The speech process starts with an expiration of air, produced by the mechanisms of lung expansion and contraction: the movements of the diaphragm and the ribs to increase or decrease the volume of the chest cavity. These movements generally depend on the functions of the upper abdominal muscles. Expiration can be passive, or it can be forcefully active, depressing the cage and starting a current of air upward from the lungs. The driving energy for speech production, generated by the mechanisms of expiration, varies with individual physiology, breathing habits, and training for correction where needed.

Phonation. In the process of phonation the current of air is vibrated in the larynx by the vocal cords, which are folds along the lateral walls of the larynx that are stretched laterally between two sets of cartilages. The coordination, size, elasticity, and health of the complex structures of the larynx, vocal cords, and intrinsic and extrinsic laryngeal muscles acting on the air current—in combination with the shaping and positioning of the vocal cords—not only produce sound but also account for the individuality of that sound.

The immediate result of vocal-cord vibration is the fundamental tone, or pitch, of the voice. In physical terms, the frequency of vibration (fast, slow, or intermediate) as the primary vocal attribute corresponds to the number of air puffs per second. This frequency, resulting in voice pitch, is determined by both stable and variable factors. Stable factors relate to the laryngeal dimensions, as determined by sex, age, and body type. Variable factors include the tension of the cords, the force of glottis closure, and the expiratory air pressure. Tension of the external laryngeal muscles affects voice pitch. For exam-



The principal speech organs, seen here in a side view (A) *and back view* (B), *include the larynx* (1), *epiglottis* (2), *tongue* (3), *mouth, and lips. Air expired from the lungs and forced through the larynx causes the vocal cords* (4) *to vibrate, producing a continuous tone—the voice. The pitch of the voice is regulated by the arrangement of the various cartilages* (5) *in the larynx, which are controlled by muscle* (6) *action. During breathing* (C), *the vocal cords* (7) *are held apart, forming a V-shaped opening. The voice is produced* (D) *when the moving cartilages* (8) *are drawn together by the muscles* (9), *forming a linear gap between the vocal cords. The cartilages tilt to regulate vocal-cord tension. Greater tension produces a higher pitch, and less tension produces a lower pitch. Loudness depends on how fast the air travels; the faster the air is forced through the gap, the louder the voice. When the voice is further modified by altering the position and shape of the other organs, speech can occur. Different vowels are produced by varying the shape of the mouth cavity. Consonants, which depend on the relative positions of the lips and tongue* (lower left), *are produced when the air is expired suddenly or stopped sharply.*

ple, a frequency of 100 vibrations per second produces the low chest sound of the male voice, whereas 1,000 vibrations per second represents the high C of a trained female soprano. An average vocal range normally encompasses 100 to 400 vibrations per second.

Resonance. The resonance process, which is fundamentally the amplification of sound on its way to utterance, involves the pharynx, the mouth, the nose, the nasal sinuses, and the chest cavity. The quality of that resonance, which may range from stridency to virtual inaudibility, also depends on both fixed and variable factors, with regard to physical conditions and learned behaviors, and relates to the intent of the individual and his or her personality as well as his or her speech behaviors. It also relates to the force of the expiration of air and the dimensions of the chest cavity. Through all the various effects and usage of these parts of the resonance mechanisms, certain types of speech mannerisms are exhibited—such as nasality, which represents overreliance on the nasal cavities for resonance; or good sound projection, which utilizes the chest cavity as well as the other organs.

Articulation. The process of articulation constitutes the formation of the amplified sound into words, through movements of the lips, tongue, and soft palate of the mouth, and of the related facial muscles. Moreover, the qualities of a given language may require different forms of articulation because the linguodental zone (between the tip of the tongue and the teeth) may be used differently in one language than the way it is in another. Universally, however, speech sounds in articulation are grouped as oral sounds or nasal sounds, and both relate to structural conditions and speech behaviors as well as to related disciplines of LINGUISTICS, SPEECH DEVELOPMENT, and pronunciation.

Speech Disorders

The existence of pathology, either functional or organic, is the basic distinction between true speech disorders and those faulty speech habits which arise from a complex of environmental, cultural, local-regional, educational, and socioeconomic factors. Another distinction, at the behavioral level, is whether the speech disorder is assessed as a handicap.

Speech disorders at the handicap level affect about 22 million persons in the United States, according to U.S. Public Health Service estimates. The highest incidence occurs developmentally among children and youths; functional disorders in articulation are the leading cause, stuttering is second, and hearing impairment with speech defect is third.

Functional Disorders. Voice disorders, or dysphonias, consist of two main types: those arising from faulty speech habits, and psychogenic types arising from emotional disturbance. Both types represent either overactive (hyperkinetic) muscular activity, creating harsh, grating speech, or underactive (hypokinetic) activity, creating subdued or sluggish speech.

Speech impediments include the following three types. Cluttering (tachyphonia) is an erratic, jerky speech. Lisping, or immature speech (dyslalia), may relate to abnormality of the external speech organs, for example, in tongue-teeth relationships. STUTTERING (dysphemia), once considered a psychogenic disorder, is now thought to be caused by neurological deficiencies present at birth or caused by injury.

Language disorders may lie between the functional and the organic, depending on the underlying cause. For example, if schizophrenia is viewed as an organic disorder, then its bizarre language is organically related. Similarly, the disturbed speech of mental retardates may be organic if the retardation is organic, or it may be a learning disability arising from the intellectual impairment. Other functional disorders include those caused by sensory deficits in the family setting, such as the presence of deaf parents; delayed maturation of motor or brain function; emotional trauma; and institutional deprivations or adverse socioeconomic factors, which result in learning disabilities related to the development of speech or such disabilities as the improper formation of word sequences.

Organic Disorders. Genetic defects and hereditary diseases include structural abnormalities of any of the organs related to vocalization and are frequently exemplified by cleft lip or cleft palate; hereditary diseases of the muscular system, such as muscular dystrophy, or of the nervous system, such as ataxia; chromosomal aberrations, such as Down's syndrome, which are associated with mental retardation; organic brain injury (genetic or birth defects); and hearing and related sensory losses. Developmental disabilities that affect speech, either directly or through learning disabilities that hamper normal speech maturation, include cerebral palsy and the associated speech disorder; epilepsy and the related convulsive seizures; damage, by injury or disease, to any of the parts involved in articulation; the learning impairments of organic mental retardation; sensory losses, auditory and visual; and other types of brain damage due to injury or disease.

Speech-center trauma in the brain occurs in two categories: damage to the speech centers and related sensory aspects of speech function (sensory aphasia), and damage to the motor-control functions of the speech centers (motor aphasia). The basic aspect of aphasia—whether due to stroke, paralysis, head injury, or disease—is the loss of the capacity for the meaning of language or its comprehensible organization into words or word sequences (Wernicke's aphasia). In other cases the intellectual functions appear to be retained, whereas the vocalization system cannot be utilized to emit words but rather only sounds (Broca's aphasia).

See also: SPEECH THERAPY.

speech development Speech development is a "robust" process that goes smoothly for most children and on that account does not constitute an obvious problem for science. It is robust, however, because it is so vital that both biological and cultural evolution have operated to safeguard its operation.

By two weeks of age, an infant can distinguish the human voice from other sounds, and by about one month, it can discriminate vowel-consonant segments such as "ba" and "pa." The speech that many parents use to talk to young children is special enough to have been given a name: the "parental register." This is a set of adjustments of approximately 100 aspects of pitch, articulation, loudness, sentence complexity, and vocabulary. It may be that the parental register facilitates language learning, but that has never been shown.

At the age of about 18 months, many children begin to make combinations of two or three words that are heard as sentences. The average length of these sentences increases gradually at rates that vary widely among individuals. There is no evidence whatever that this variation in rate predicts adult intelligence. The first sentences are always composed primarily of nouns and verbs, and everywhere in the world the most frequent forms in the language—words like articles and prepositions and word parts like inflections for plural number and past tense—are omitted. Early child sentences have a "telegraphic" quality. They also share a limited subject matter. They name people, foods, toys, pets, and body parts and remark on their disappearance and reappearance as well as their usual locations and the simple actions in which these objects take part.

As the preschool years pass, the rules grow in complexity, and the child can soon do more than string out simple sentences; he or she can embed or nest them, one in another. At about the same point or a little later, the child learns that some sentences can be made into a more compact structure by deleting shared portions and joining the rest with a conjunction.

By the time the child is of school age he or she can state no grammatical rules at all but may be extremely articulate. In grade-school years, the child adds a few grammatical rules of special complexity but is primarily occupied with larger expository structures of which sentences are now the atomic units.

Certain grammatical mistakes, for example, "He hurt hisself" and "Why the car won't go?" are good errors suggested by analogy with correct forms. The errors show that the child's brain is extracting a set of rules that will make it possible to create an infinite variety of sentences. This is the central phenomenon of speech development. It sets the major theoretical problems, including that of distinguishing between innate and learned knowledge.

Extreme theoretical positions on the development of speech have long been championed by the psychologist B. F. SKINNER and the linguist Noam CHOMSKY. Skinner contends that "verbal behavior" is learned in accordance with general principles of positive and negative reinforcement, which he believes account for all learning in all animal species. Chomsky holds that the "competence" to produce an infinite variety of sentences, the routine outcome of language development in the preschool years, can never be explained by any learning theory or set of data-processing procedures. It is necessary, in Chomsky's view, to postulate innate knowledge (corresponding to linguistic universals) of the types of linguistic rules that are possible and the types that are impossible. A language-specific "acquisition device," which Chomsky does not hesitate to call a "mental organ," might then sample linguistic input and hit on the correct rules underlying that input.

The developmental psychologist Jean PIAGET never took a position on the complex problems of grammar acquisition. Several developmental psycholinguists who are persuaded of the general applicability of Piaget's theories to all aspects of development, however, have done research on grammar acquisition within a Piagetian framework.

All three theories have served to inspire empirical research in PSYCHOLINGUISTICS, but Chmosky's ideas have been far more influential than the others. The most important feature of Chomsky's theory is its emphasis on possible universals of linguistic development. As yet, it cannot be said that the results clearly support any of three general theories.

speech therapy Speech therapy is the process by which impairments of normal speech, such as STUTTERING, stammering, and APHASIA, are treated in an effort to permit normal voice communication by the individual. The conduct of speech therapy is one of the functions of the profession now known as speech/language pathology. In addition to treating speech and language problems, the speech/language pathologist also diagnoses the nature of communicative disorders and determines their causes. Specialists in this field also provide counseling to individuals with speech and language disorders and engage in research relating to communicative disorders and their possible causes and treatment.

Speech pathology first emerged as a specialty during and immediately after World War I. By 1925 a national association of people engaged in the field had been organized, now known as the American Speech and Hearing Association.

See also: SPEECH.

speed Speed is the distance an object moves during a unit of time. Common units of speed are meters per second (m/sec) and miles per hour (mph). Speed refers only to the rate of motion without specifying any direction of motion. It therefore differs from VELOCITY in a technical sense, because velocity is a vector quantity and specifies a direction.

See also: MOTION, PLANAR.

speedball Speedball is a unique sport in which teams of 11 compete on a regulation football field using a soccer ball. Play begins with a kickoff, as in football, and continues for four 10-minute periods. The game progresses by means of the players throwing, punting, or dropkicking the ball and taking only one step while holding the ball.

Although there are some differences in scoring the men's and women's versions of the game, there are five ways to score: a field goal, worth 3 points, is scored by kicking or using the body to send the ball between the goalposts but under the goal crossbar; a touchdown, worth 2 points, is scored by catching a forward pass in the opponent's end zone; a dropkick, worth 2 points, is scored by catching the ball in flight and drop-kicking the ball over the crossbar; and an end kick (kicking the ball across the end line from within the end zone) and a penalty kick (a free kick allowed after a foul), each worth 1 point.

Speer, Albert [shpayr] The German Nazi leader Albert Speer, b. Mar. 19, 1905, d. Sept. 2, 1981, directed Germany's war production, using slave labor, during World War II. Speer, who joined the National Socialist party in 1931, became Adolf Hitler's architect, designing the Nuremberg stadium and other Nazi monuments. He was made minister of armaments in 1942 and expanded his planning responsibilities over most of Germany's wartime industry in 1943. In 1946 he was sentenced to 20 years in Spandau prison by the Nuremberg tribunal.

Speke, John Hanning [speek] English explorer John Hanning Speke, b. May 3, 1827, d. 1864, was the first European to reach the source of the Nile River. He joined Sir Richard BURTON in 1856; after exploring East Africa with Burton, Speke continued alone and on July 30, 1858, discovered Victoria Nyanza (see VICTORIA, LAKE), which he identified as a source of the White Nile. In 1861–63, Speke led a further expedition, locating another source of the great river, but Burton disputed his claims of discovery. On Sept. 18, 1864, the day that they were to meet in public debate, Speke accidentally shot and killed himself.

speleology [spee-lee-ahl'-uh-jee] Speleology is the study of CAVES. It encompasses their geology, geography, biology, and history. Thus, studies of karst (limestone) topography and groundwater hydrology (flow of water through caves) are included as parts of speleology. One of the newest of sciences, speleology has had an extraordinary expansion since 1950 and has produced unifying principles leading to wide-ranging conclusions about the origin of caves, their environment, their actual measurements, their age, and the life cycles of cave animals. Speleological research has led to the economic utilization of caves as sources of water and as storage areas, the mining of cave-related minerals, and the gathering of data about early human cultures.

Spellman, Francis Joseph Cardinal Francis Joseph Spellman, b. Whitman, Mass., May 4, 1889, d. Dec. 2, 1967, was one of the most influential church figures in American history. During his years as archbishop of New York (1939–67) he was close to five American presidents, especially Franklin D. Roosevelt. He was also deeply involved in the delicate diplomatic maneuvering during World War II. Spellman, created a cardinal in 1946, was a staunch anticommunist and identified closely with the soldiers of the U.S. armed forces.

Spelman College Established in 1881, Spelman College is a private Baptist liberal arts school in Atlanta, Ga. It is America's oldest college for black women and one of the six schools of the Atlanta University Center.

spelunking [spuh-luhng'-king] Spelunking is the amateur pursuit of speleology, the exploration and study of caves as a hobby or sport. It is a popular recreation in parts of the world where there are caves. Spelunkers vary from casual explorers out for a day's adventure to highly sophisticated experts using specialized equipment. Most cave exploration, however, is still conducted by professional scientists. In many cases spelunkers must be accomplished climbers in order to descend into deep pits, boaters to navigate underground rivers and lakes, and divers to examine water-filled caves.

Spencer, Herbert Herbert Spencer, b. Apr. 27, 1820, d. Dec. 8, 1903, was Victorian England's major philosopher of biological and social EVOLUTION. An editor of and contributor to scholarly journals in his early career, he won a large popular following for his optimistic view that evolution is synonymous with progress. His work significantly influenced 19th-century developments in biology, psychology, sociology, and anthropology. Spencer's book *The Principles of Biology* (1864–67) was used as a text at Oxford University; his *The Principles of Psychology* (1855) became a text at Harvard University; and his *Study of Sociology* (1873) was Yale University's textbook for the first course offered in that field in the United States.

Spencer's significance to these disciplines is that he was one of the first to affirm that human society may be studied scientifically and that he did so from an evolutionary point of view based on the assumption that human behavior is socially determined. His evolutionary theories predated those of Charles DARWIN, and Spencer is thought to have coined the phrase "survival of the fittest." In his three-volume work, *Principles of Sociology* (1876–96), Spencer clarified his belief that social structures arise out of social functions.

Spender, Stephen The British poet Stephen Spender, b. Feb. 28, 1909, became associated at Oxford University with W. H. Auden, C. Day Lewis, and Louis MacNeice. These writers were greatly affected by the political events of the 1930s. In response, Spender, like the others, adopted a form of Marxist political belief. These events are also reflected in his poetry as the causes of his carefully described personal feelings. Spender's autobiography, *World within World* (1951), is a valuable record of the intellectual enthusiasms of the 1930s and '40s; *The Struggle of the Modern* (1963) describes the transitions of literary taste that have taken place since the publication of the early poems of T. S. Eliot and Ezra Pound.

Since the modest *Selected Poems* appeared in 1965, Spender has written relatively little verse but continues to be a notable public figure. He was coeditor from 1939 to 1941 of *Horizon,* an important magazine, and of *Encounter* from 1953 to 1967. When he discovered that *Encounter* was secretly financed by the U.S. Central Intelligence Agency, he resigned.

Spener, Philipp Jakob [shpay'-nur] German Lutheran theologian Philipp Jakob Spener, b. Jan. 23, 1635, d. Feb. 5, 1705, is called the father of PIETISM. While senior minister of Frankfurt am Main, he produced his pietist manifesto, *Pious Desires* (1675; Eng. trans., 1964), outlining a program of church reform. Deploring ceremonialism, government domination, and theological hairsplitting, Spener proposed group study of the Bible, the priesthood of all Christians, the resolution of controversy by prayer and example, and a ministry trained in devotion and spiritual preaching. In 1686 he became chief pastor at the Saxon court, but he came into conflict with the theologians of Leipzig and moved (1691) to Saint Nicholas's Church in Berlin, where he headed the Pietist party.

Spengler, Oswald [shpeng'-glur] Oswald Spengler, b. May 29, 1880, d. May 8, 1936, a German historian and philosopher, developed a pessimistic philosophy of history that earned him considerable renown. In 1918 the publication of the first volume of his *The Decline of the West* (2 vols., 1918–22; Eng. trans., 1932) brought him fame. Spengler held that history followed definite laws of growth and decay that are observable in the careers of all cultures. Tracing the unfolding of these laws in his own era, he predicted that Western culture, already well into its twilight, would experience further decline as a future of rationalism, mass manipulation, and material expression succeeded the profound art, religion, and philosophy of the past. In later nationalistic political tracts Spengler contended that Germany, with its Prussian authoritarian tradition, could dominate this future.

Spenser, Edmund Edmund Spenser, b. London, *c.*1552, d. Jan. 13, 1599, was the greatest of Elizabethan nondramatic poets. Although he was acclaimed after his death as "Prince of poets," during his lifetime he did not enjoy the unstinting favor of the queen, who may have found his poetry too subtle and equivocal to be used as propaganda.

From his first major work, the anonymously published *The Shepheardes Calendar* (1579), Spenser was nevertheless recognized as a major poet who could adapt the new continental poetry to a native English setting. His long allegorical epic, The FAERIE QUEENE, unfinished at his death, attempted to provide Elizabethan England with a poem comparable to Vergil's *Aeneid.* Although it has disappointed readers looking for either the unified plot of classical epic or the unambiguous moral lessons of allegory, it has been admired by others who recognize it as a triumph of art. Modern critics have likened Spenser's profound sense of the possibilities of language to that of such modern writers as James Joyce.

Education. Spenser's education at Merchant Taylors' School under the classical scholar Richard Mulcaster and at Cambridge, where he met the learned Gabriel Harvey, exposed him to both ancient and modern literatures. In 1569, the year he entered Cambridge, he published translations from Du Bellay and from Marot's version of Petrarch for a book of emblems compiled by Jan van der Noodt. *The Shepheardes Calendar* was a book of pastoral eclogues, printed with introduction and notes by an unidentified "E. K.," possibly Edward Kirke, a friend of Spenser's, or the poet himself. Signing himself *Immerito,* "Without Merit," and dedicating the volume to Sir Philip Sidney, Spenser invited (and received) comparison with the eclogues of Vergil. In later pastoral works, Spenser used the name of the lovesick shepherd of this volume, Colin Clout, as his pseudonym.

Ireland. After a brief period in the service of the earl of Leicester, Spenser became secretary to Arthur Lord Grey, Elizabeth's Lord Deputy to Ireland, in 1580 and was to serve in Ireland in various capacities for most of the remainder of his life. On publication (1590) of the first three books of *The Faerie Queene,* he received an annual pension of $50 from the queen; he was not fortunate as a courtier, however, and saw more than his share of the dark side of Elizabeth's Irish policy, although he tried to justify it in his *Vewe of the Present State of Ireland* (publ. 1633). Frustration and disappointment are reflected in his later writings: *Complaints* (1591), *Daphnaida* (1591), *Colin Clouts Come Home Againe* (1595), *Prothalamion* (1596), and books 4–6 of *The Faerie Queene* (1596). An exception may be *Amoretti and Epithalamion* (1595), which celebrates his courtship and marriage. Spenser died shortly after returning to England and was buried in Westminster Abbey.

Edmund Spenser was the most acclaimed poet of Elizabethan England. His Faerie Queene *brilliantly combines the literary traditions of the classical epic, moral allegory, medieval verse narrative, and courtly romance.*

Speransky, Mikhail Mikhailovich [spir-ahn'-skee] The Russian statesman Mikhail Mikhailovich Speransky, b. Jan. 12 (N.S.), 1772, d. Feb. 23 (N.S.), 1839, was one of the most gifted civil administrators of his time. As virtual prime minister to Emperor ALEXANDER I, Speransky drafted several reform projects—including a constitution—for Russia. Cold and austere, Speransky was never popular at court, and his enemies had him exiled in disgrace in 1812. He reentered the civil service in 1816 and returned to Saint Petersburg in 1821. After the accession (1825) of Emperor NICHOLAS I, Speransky worked until 1833, codifying the empire's laws.

sperm Sperm, or spermatozoon, is a broadly used term for the diverse types of motile male gametes (sex or reproductive cells) found in all animals and lower plants. Each sperm contains the paternal genetic information to be contributed through FERTILIZATION to the resulting offspring. Its secondary function is to initiate EGG development. Commonly, the spermatozoon has a head with a nucleus but little cytoplasm, and a tail, or flagellum, used for locomotion. The cell, excluding the tail, may be only 50 to 60 μm, and a sperm may be only 1/195,000 the size of an egg. A wide range of shapes and sizes, however, exists. Each cell can swim in an aqueous medium to reach an egg. In higher animals, sperm cells are produced (spermatogenesis) by germ cells in the male testes and conveyed to the outside in a viscous fluid called SEMEN. Mammalian sperm may be stored for long periods of time, through freezing, for use in ARTIFICIAL INSEMINATION.

See also: REPRODUCTION.

sperm oil Sperm oil is the oily substance taken from the head and sometimes the fat and bones of the sperm WHALE. The head, comprising one-third of the whale's total length, may contain up to 50 barrels of the oil, which has been valued for centuries as a fuel for lamps; a lubricant for precision instruments; an ingredient of soaps, detergents, and cosmetics; and a softener and preserver of leather. Sperm oil is classed chemically as a liquid wax. It contains another waxy substance, spermaceti—so called because it was thought to be the coagulated semen of the whale—which is removed from the oil by chilling.

Spermaceti is used in making ointments, pomades, face creams, and candles. Whale oil, which is taken from baleen whales such as the blue and the humpback, is a genuine fat.

spermatophyte [spur-mat'-uh-fyt] *Spermatophyte*, or, literally, seed plant, is a term used to refer to those plants which bear true seeds; the term encompasses all flowering plants (ANGIOSPERMS), such as roses and palm trees, and all "nonflowering" plants with true seeds (GYMNOSPERMS), such as pine trees and the ginkgo. In older classifications the spermatophytes were also called phanerogams (*phanero*, "visible"; *gam*, "sexuality") because the sexual structures (stamens and pistils) of these plants were plainly evident. The group term Spermatophyta is not used in most modern classification systems.

Sperry, Elmer Ambrose The work of the inventor and engineer Elmer Ambrose Sperry, b. Cortland, N.Y., Oct. 21, 1860, d. June 16, 1930, marks the transition in the history of American technology from the age of invention to the era of corporate research and development. Sperry received more than 350 patents in such diverse fields as electric power, aviation, and industrial chemistry, most of them relating to automatic control systems. After receiving (1880) his first patent on a dynamo-electric machine, Sperry became an independent inventor. He established invention, development, and manufacturing companies and staffed them with engineers and scientists. In 1907 he became interested in GYROSCOPES. He developed the Sperry gyrostabilizer, a gyrocompass for ships, and established (1910) the Sperry Gyroscope Company, the progenitor of the Sperry Rand Corporation.

sphalerite [sfal'-ur-yt] Sphalerite (ZnS), a common and widely distributed zinc SULFIDE MINERAL, is the major ore of zinc. Found in a variety of crystal forms (isometric system) as well as in cleavable, granular, or foliated masses, it ranges from colorless to brown and black in color, darkening as the amount of iron impurities increases. Hardness is 3½ to 4, streak is brownish, luster is resinous to adamantine, and specific gravity is 3.9 to 4.1. Sphalerite, usually in association with the lead sulfide galena, occurs in contact metamorphic deposits, in replacement deposits within limestone and dolomite, and in veins.

sphene Sphene [$CaTiSiO_4$ (O,OH,F)], also called titanite, is a titanium and calcium SILICATE MINERAL. When transparent and of good color, it is faceted to produce a brilliant, multicolored GEM. Sphene forms wedge-shaped crystals (monoclinic system) of various forms and granular masses that range in color from brown to black through gray and green to yellow and red. Hardness is 5 to 5½, luster is adamantine to resinous, and specific gravity is 3.4 to 3.6. Sphene occurs as an accessory mineral in igneous rocks, notably nepheline syenites, and in gneisses, schists, and marbles.

sphere A sphere is the set of all points in space that are equidistant from a fixed point called the center. Any line segment drawn from the center to the surface of the sphere is called a radius; the length of this segment is also called the radius. A chord is any line segment that has both endpoints on the sphere. A diameter is a chord that passes through the center. If the radius is r, then all points less than r units from the center constitute the interior of the sphere, whereas the exterior is the set of all points that are more than r units from the center.

A sphere may be generated by rotating a circle about any one of its diameters. For example, a coin will trace out the surface of a sphere when it is given a spin. The sphere with center at point (a,b,c) and radius r has the equation $(x-a)^2+(y-b)^2+(z-c)^2=r^2$. If the center is at the origin of the coordinate system, the equation reduces to $x^2+y^2+z^2=r^2$. A sphere of radius r has volume $V = \frac{4}{3}\pi r^3$, and surface area $A = 4\pi r^2$.

spherical coordinates see COORDINATE SYSTEMS (mathematics)

spherical trigonometry Spherical trigonometry is a branch of geometry that deals with triangles that can be drawn on the surface of a sphere (spherical triangles). It should be distinguished from the ordinary TRIGONOMETRY of plane figures. A spherical triangle is bounded or defined by three arcs, called arcs of a great circle. Planes passing through arcs of a great circle also pass through the center, or origin of the sphere. The shortest distance between two points on a spherical surface is determined by the arc of a great circle that connects the two points.

The size of the angle between two arcs of a great circle is given by the dihedral angle at the intersection of the corresponding planes of a great circle. The distance along the arc of a great circle between two points can be represented by the angle between two radial segments that join the ends of the arc with the center of the sphere.

Another important measure on a spherical surface is the spherical degree. A spherical degree is the amount of area on the surface of a sphere equal to 1/720 of the whole surface. It is defined by the spherical triangle known as a birectangular spherical triangle, whose angles are two right angles and a third angle of one ordinary degree.

The position of a point in space can be described by Cartesian (or rectangular) coordinates, or by spherical (or polar) coordinates (see COORDINATE SYSTEMS). In the spherical system a point P can be described by three quantities: its distance from a fixed point O, the angle ϕ between an initial line OZ and a line through OP, and the dihedral angle θ between the initial plane through OZ and the plane containing OP and OZ. The point O is called the pole; the symbol r is given to the length OP (the radius vector); θ is the longitude (azimuth); and ϕ is called the colatitude of the system.

The coordinates of P are written (r, θ, ϕ). The spherical coordinates are related to the Cartesian coordinates by associating the pole with the origin and the polar axis (through OZ) with the z-axis. The initial plane coincides with the zx-plane, and θ is the angle between the positive direction of the x-axis and the projection of OP on the xy-plane. The rectangular and spherical coordinates of any point P in space are related in the following way:

$$x = r \sin \phi \cos \theta \qquad r = (x^2 + y^2 + z^2)^{1/2}$$
$$y = r \sin \phi \sin \theta \qquad \tan \theta = y/x$$
$$z = r \cos \theta \qquad \tan \phi = (x^2 + y^2)^{1/2}/z$$

sphinx A mythical creature that originated in ancient Egypt, the sphinx combined a beast's body (usually a lion's) with the human face of the ruling pharaoh. Large-scale examples carved in stone often served to guard sanctuaries in ancient Egypt. Although usually depicted in a recumbent position, some sphinxes were shown trampling Egypt's foes. The sphinx image also appeared in various forms among other ancient cultures of Western Asia and the Mediterranean, notably in Mesopotamia, Greece, and Etruria. Wings were often added to the leonine body, and female sphinxes were also created, especially in Greece (8th–6th century BC). The most famous sphinx lies near the pyramid (see PYRAMIDS) of KHAFRE at Giza, 10 km (6 mi) from Cairo. Originally built to guard the pyramid, this sphinx was later worshiped as the god Rahorakhty, "Ra of the Two Horizons." Unfortunately, its nose, used by soldiers of a later era for target practice, is now missing.

Spice Islands see MOLUCCAS

spice trade Since ancient times the aromatic spices of the Far East have been in demand by peoples of the East and West, and control of the lucrative trade in these spices has been highly coveted. Because the primary source of aromatic spices has been concentrated in the MOLUCCAS (or Spice Islands) in the East Indies, control has tended to be monopolistic.

The overland transport of spices to China and Arabia began long before the Christian era, but the large-volume, primarily seaborne, trade developed later. The first major monopoly arose in the 9th century among Indian traders operating from Java. In the 12th century other Indians—Muslim traders cooperating with Arab and Persian sailors—began encroaching on the trade, gaining control of the port of MELAKA around 1450 and of all Java by 1528.

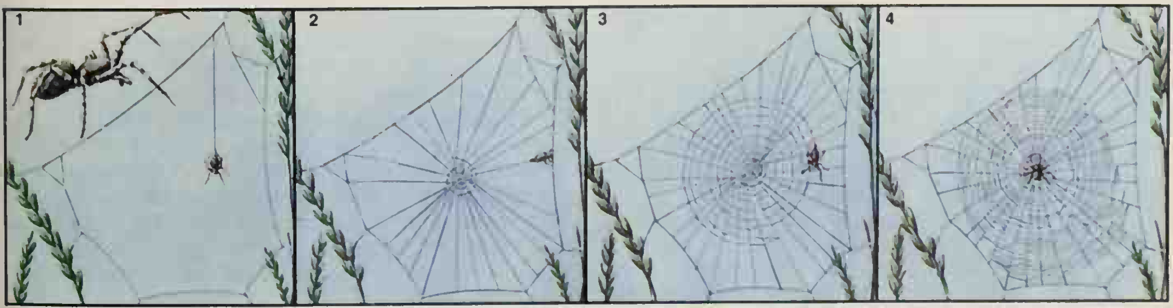
Many Europeans in the age of discovery were, like Christopher COLUMBUS, spurred in part by a desire to reach the source of the much-valued spices. The Portuguese, after rounding Africa and reaching India, captured Melaka in 1512 and dominated the trade for the rest of the century. Dutch and British fleets drove Portugal from Asian waters after 1600, but the Dutch seized Melaka in 1641 and denied the British access to the Moluccas. They established the profitable Dutch EAST INDIA COMPANY and—except for some intervals of British domination—controlled the spice trade into the 20th century.

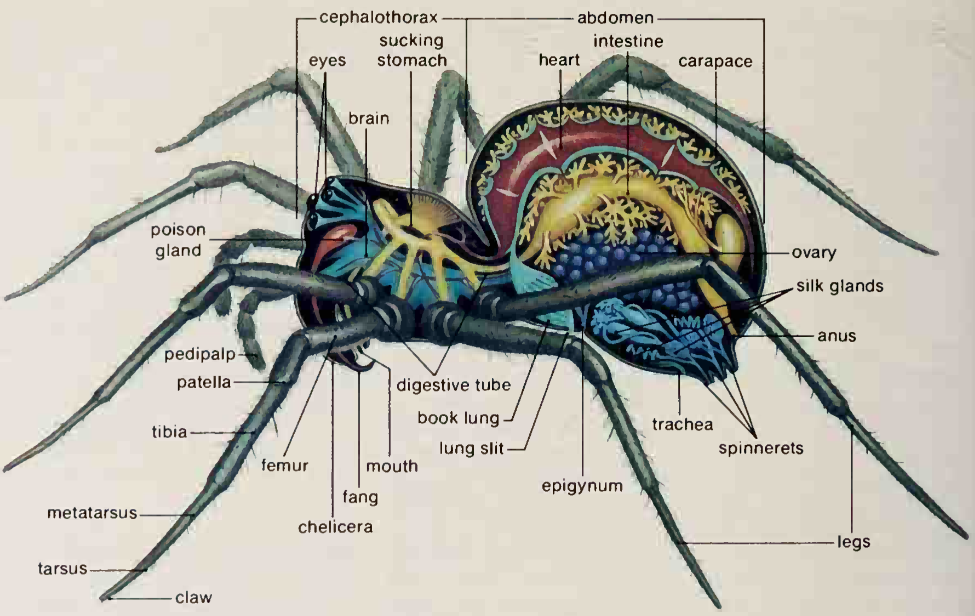
spicebush The common spicebush, *Lindera benzoin*, grows in wooded bottomlands of eastern North America. It bears clusters of small yellow flowers in early spring and small, bright red berries in summer. The leaves, twigs, and bark of this spicy-scented shrub have been used to make tea. Dried and powdered spicebush berries are known as a substitute for allspice.

spider Spiders comprise a large, widespread group of carnivorous arthropods. They have eight legs and can produce silk, and most have poison glands associated with fangs. The more than 30,000 species of spiders are found on every continent except Antarctica in almost every kind of terrestrial habitat and a few aquatic ones as well. Spiders range in body size from about 0.5 mm (0.02 in) to 9 cm (3.6 in).

Classification. Spiders constitute the order Araneae (class Arachnida), which is usually divided into 2 suborders. The suborder Orthognatha, or mygalomorph spiders, has about 12 families and includes the trap-door spiders,

An orb weaver spider begins its web by spinning a single thread, the bridge line, that is carried by wind until it attaches to a twig or other object. The spider then lays down other foundation lines (1). *Radial threads* (2) *are connected between the foundation lines and an attachment zone near the center of the web. Next, the spider lays down a nonsticky scaffolding spiral* (3) *that holds the radials in place. Finally, the spider spins a spiral of viscid, or sticky, threads* (4) *and removes the temporary scaffolding.*





The anatomy of a spider, an arachnid, includes four pairs of legs and a body divided into two regions, the cephalothorax and the abdomen. The spider produces silk from spinnerets located in its abdomen and uses the silk to spin webs, to line its burrow, to wrap its eggs in cocoons, and to lower itself by a single strand to the ground. Its scientific class, Arachnida, is named for the Greek tapestry weaver Arachne, who was turned into a spider by the goddess Athena.

family Ctenizidae, and the large tarantulas, family Theraphosidae. The suborder Labidognatha, or araneomorphs, with about 60 families, contains the true spiders and includes most of the familiar ones. Among the major families are those which capture prey in webs—Araneidae, or orb weavers; Theridiidae, which include the notorious black widow; and Agelenidae, which capture prey that lands on their sheet webs—and those which hunt—Lycosidae, or wolf spiders, mostly nocturnal; Salticidae, or jumping spiders, diurnal with excellent eyesight; and Thomisidae, or crab spiders.

Structure and Function. Spiders have two major body parts, the cephalothorax and the abdomen, which are connected by a thin pedicel. The cephalothorax bears six pairs of appendages. A pair of chelicerae with fangs associated with food capture is followed by a pair of leglike pedipalps, which are modified in adult males as intromittent organs for the transfer of sperm to the female. Behind the pedipalps are four pairs of walking legs. Pedipalps and legs often have many sensory hairs. The legs have seven segments and usually bear two or three claws at their apex. The top of the cephalothorax is covered by a carapace with usually four pairs of simple eyes on the anterior end. The abdomen is usually unsegmented, and its ventral surface has the genital openings.

The hemolymph (blood) of the circulatory system is used for both the distribution of food and oxygen (some spiders having the bluish oxygen-carrying pigment, hemocyanin) and the hydraulic system by which the legs are extended by blood pressure. Spiders use two systems for respiration: thin tubes, or tracheae, which ramify from abdominal openings (spiracles) and book lungs, which are groups of thin-walled invaginations that open on either side of the genital region at the anterior end of the abdomen. Most true spiders have both tracheae and a pair of book lungs.

The spinnerets are fingerlike appendages usually located at the spider's posterior end and supplied with liquid protein silk by silk glands within the abdomen. The protein polymerizes into dry silk as it is pulled out of the tiny spigots covering the four to eight spinnerets. The silk is used for trap building, lining tubes and cavities, wrapping eggs, wrapping prey, as safety lines, and, in small spiders, as a way to "balloon," or to be carried by the wind.

All spiders have movable fangs at the ends of their chelicerae, and most have poison glands that open at the tips of the fangs. The poison is effective on arthropods, and a few spiders have poisons toxic to vertebrates, including humans. In the United States, the black widow, *Latrodectus mactans*, has a potent neurotoxin, and the brown recluse, *Loxosceles reclusa*, possesses an ulcer-producing poison. Most spiders, however, are quite harmless to humans.

Predaceous animals that feed primarily on other insects, spiders usually kill prey with their poison. Because spiders can swallow only liquids, digestive juices are pumped out onto the prey, where digestion occurs externally. The spider then swallows the resulting nutritive soup.

Spiders use several strategies to capture prey: active hunting, waiting in ambush, and making and using traps of silk. The most distinctive strategy is the use of a silk orb web. This aerial net uses a minimum of silk threads to "strain" the air for insect prey of the proper size. Most orb webs are made up of strong support threads for the frame and radii, which radiate from the hub, and a spiral sticky thread that makes up the catching surface. The spider often sits at the hub with each of its legs on a different radiating thread. When a prey is caught, the spider can feel its vibrations; it runs rapidly to the prey and quickly bites it or wraps it in silk. Some webs reflect ultraviolet light to lure insects to the web.

Reproduction. Reproduction is sexual. The male makes a simple sperm web and deposits a drop of sperm on it from his genital pore. The sperm is then taken up by the copulatory organs at the ends of his pedipalps. The male finds a female, courts her, and then mates—inserting the pedipalps into special openings on the underside of the female's abdomen, where the sperm is deposited. Within days the female will construct a silken egg case; the eggs are fertilized as they are laid into the egg case. Development begins in the egg sac, and the first molt usually takes place there. After emerging, the spiderlings undergo from 5 to 15 molts in direct development to the mature form. In some spiders the mother protects her young for a few days after emergence.

Importance. Spiders play an important role in natural ecosystems as insect predators, and spider silk is used commercially in the preparation of cross hairs in optical instruments. Spiders are used to test certain drugs, because drugs given to spiders can affect their web building.

spider plant The spider plant, *Chlorophytum comosum*, of the lily family, Liliaceae, is an evergreen native to South Africa but now widely cultivated and a popular houseplant. Its narrow leaves can grow up to 46 cm (18 in) long and may be solid green or have yellow or white stripes down the center or margins, depending on the variety. Small white flowers grow on separate stalks. Young plants develop on these stalks and cause them to droop, producing a "spidery" appearance.

spiderwort [spy'-dur-wurt] Spiderwort is the common name for the more than 20 species of perennial herbs in the plant genus *Tradescantia*, in the spiderwort family, Commelinaceae. They are so called because of the hairy flower stalks enclosed by sheathing leaves at the base. Several species are common house and greenhouse plants, including purple selections of *T. fluminensis* (WANDERING JEW) and *T. virginiana*.

Spielberg, Steven [speel'-burg] The filmmaker Steven Spielberg, b. Cincinnati, Ohio, Dec. 18, 1947, worked in television prior to his film debut in *The Sugarland Express* (1974). With *Jaws* (1975), he began his string of box-office hits that included the action-fantasy films *Close Encounters of the Third Kind* (1977); *Raiders of the Lost Ark* (1981) with the sequels *Indiana Jones and the Temple of Doom* (1984) and *Indiana Jones and the Last Crusade* (1989); and *E.T.: The Extra-Terrestrial* (1982). In *The Color Purple* (1985) and *Empire of the Sun* (1987) Spielberg explored more serious subject matter. His *Always* (1989) was a remake of a 1943 film. He also produced *Who Framed Roger Rabbit* (1988).

Spillane, Mickey [spil-ayn'] An American mystery writer, Mickey Spillane, b. Frank Morrison in Brooklyn, N.Y., Mar. 9, 1918, created the private eye Mike Hammer and became a best-selling author. The formula for the Hammer novels was established in *I, the Jury* (1947; film, 1953), which relies on violence and sex and on Hammer's remorseless desire to punish wrongdoers who escape justice. Several Spillane novels have been filmed. Later works include *The Death Dealers* (1965), *Survival: Zero* (1970), and *The Killing Man* (1989). He also has written two children's books.

spina bifida [spy'-nuh by-fi-duh] Spina bifida is a BIRTH DEFECT in which part of the spinal column (the bony structure that surrounds the spinal cord) does not close properly, so that a segment of the cord is left exposed. The defect may involve only a few vertebrae, or it may leave a major section of the cord uncovered. The cord or membranes surrounding the cord, or both, may protrude. The nerves in the protruding sac are protected by only a fragile membrane and can easily be damaged or infected. If untreated, most infants with spina bifida die of infection; many others are left with severe disability. In the United States the defect occurs in approximately 1 out of every 1,000 live births.

Starting in the 1960s, some hospitals instituted new surgical procedures soon after birth to replace the exposed nerves within the spinal cord and to alleviate the HYDROCEPHALY associated with spina bifida. This surgery, combined with more intensive efforts at rehabilitation, has brought many spina bifida babies to adolescence in an independent state. Despite extensive therapy, however, many others still suffer handicaps ranging from difficulty in walking to quadriplegia, incontinence, and mental retardation.

No cause is known for spina bifida. It usually appears in a family with no prior history of the condition, but once a woman has one such child she has a 5% probability of bearing another. A blood test that detects most cases by the fourth month of pregnancy is available.

spinach Spinach is an annual herb, *Spinacia oleracea*, which is grown for its nutritious green leaves. Believed to have originated in southwestern Asia, it was introduced into Europe during the Middle Ages and is now

Spinach must be planted in early spring or fall because it goes to seed quickly in hot weather. Both wrinkled and smooth-leaved varieties grow in broad rosettes.

widely cultivated throughout the world. The United States, the Netherlands, and the Scandinavian countries are the major producers. Within the United States, California is the leading state for growing commercially processed spinach, and Texas is the major producer of fresh-market spinach. Spinach thrives in relatively cool weather. Generally, spinach plants have either male flowers or female flowers. Female forms are slower to bolt, a characteristic that led to the development of warm-weather varieties in which the plants are primarily female. Under good growing conditions, spinach is ready for harvest about 40 days after seeding. Picking may begin after five leaves have developed and can continue until the seedstalks develop.

spinal cord The spinal cord, a tube about 1 cm (0.4 in) thick with a small central canal, is present within the vertebral column of all vertebrate animals, where it runs from the brain stem, at the level of the first cervical (neck) vertebra, to the tail. A cerebrospinal fluid flows through the central canal and around the spinal cord. The cord is encased in three layers of membranes: the dura mater, the pia mater, and the arachnoid. Together with the BRAIN, the spinal cord constitutes the central NERVOUS SYSTEM.

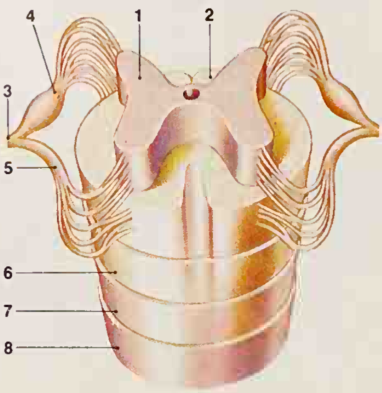
In cross section, the spinal cord has a centrally positioned butterfly-shaped gray area surrounded by white matter. The gray color comes from unmyelinated cell bodies of nerve cells (neurons), the white from the myelinated axonal fibers.

A cell body contains the nucleus of the nerve cell, and it sends out a single axon and numerous fibrous extensions known as dendrites—short, branchlike processes. In the spinal cord, dendrites receive stimuli from the axons of other neurons whose cell bodies are located either elsewhere in the central nervous system or in the peripheral nervous system. The latter consists of all nerve cells whose axons lie outside of the brain or spinal cord.

Thirty-one pairs of spinal nerves are present in humans, and each pair has two roots. The ventral roots, located at the front side of the spinal cord, stem from ventral or lateral horns and carry the initial segment of motor-neuron axons. The dorsal roots, positioned at the back side of the cord, carry the terminal segments of sensory neurons, whose terminal branches lie within the dorsal horn of the spinal cord. The cell bodies of the sensory neurons are located within a spinal ganglion adjacent to the cord, and their dendrites are located in the skin, the belly of muscles, the tissues of soft organs (viscera), and blood vessels.

The dorsal horns lie on the back side of the spinal cord, where the incoming sensory neurons form synapses with dendrites of neurons carrying information to the brain, or with motor neurons, to form a REFLEX arc. Ventral horns, which are located at the belly side of the spinal cord, contain the cell bodies of motor neurons. These carry impulses from the spinal cord to the body. Lateral horns, present only in the thoracolumbar region, are situated between the dorsal and ventral horns; they protrude laterally and contain cell bodies of neurons from the autonomic nervous system. The axons of these neurons are carried, together with the axons of motor neurons, in the ventral roots. Immediately outside of the spinal cord, just before leaving the vertebral column, the ventral and dorsal roots unite into a spinal nerve on each side of the body.

As seen in cross section, the spinal cord consists of gray matter (1) surrounded by white matter (2). Each spinal nerve (3) divides into a dorsal sensory root (4) and a ventral motor root (5). Both the brain and spinal cord are enclosed by three protective membranes, or meninges: the pia mater (6) and the arachnoid (7)—which enclose the cerebrospinal fluid—are surrounded by the dura mater (8).

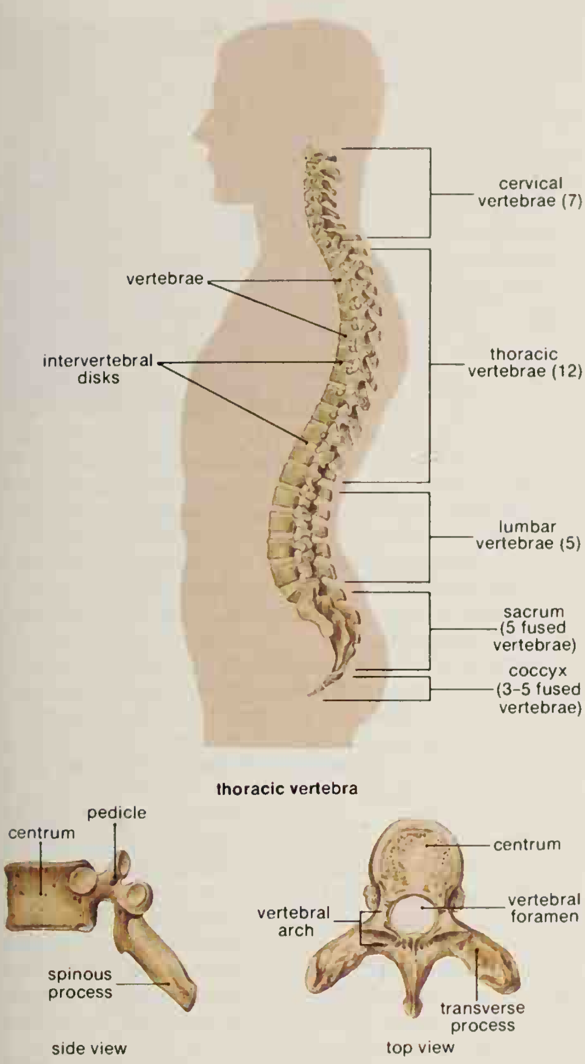


spindle tree Spindle tree is the common name for about 170 species of deciduous and evergreen trees, shrubs, and woody creepers of the genus *Euonymus* in the staff-tree family, Celastraceae. Most are native to Asia. The name was originally applied to *E. europaea*, because its hard wood was used to make spindles. The stems are four-angled, the flowers are small and are greenish or purplish, the fruits are 3- to 5-valved capsules, and the seeds are enclosed in a reddish cover. A number of species are cultivated, including the winged spindle tree, or burning-bush, *E. alatus*, native to temperate eastern Asia; the strawberry-bush, or wahoo, *E. americanus*, of the eastern United States; the wintercreeper, *E. fortunei*, from China; and the Japanese spindle tree, *E. japonicus*, from Japan.

spine The spine, or spinal column, consists of bone and forms the primary support of the skeleton in vertebrates. The functions of the spine are the protection of the SPINAL CORD and the roots of the spinal nerves and the provision of attachment points for the skull, ribs, pelvis, muscles, and ligaments.

The flexible portion of the spine, or backbone, in humans consists of 24 individual vertebrae: 7 in the neck (cervical vertebrae), 12 in the thorax (thoracic vertebrae), and 5 in the lower back (lumbar vertebrae). The sacrum, located below the lumbar vertebrae and joined to the pelvis, consists of 5 fused vertebrae. The coccyx, or tailbone, is located below the sacrum and consists of 3 to 5 fused, rudimentary vertebrae.

In general, the major part of a vertebra, the body, is a short, solid, cylindrical structure called the centrum. The remaining part is called the vertebral arch, or neural arch. The spinal cord passes through the large hole, or foramen, in the center of each vertebral arch of the spinal



The human spine consists of 7 cervical vertebrae, 12 thoracic vertebrae, and 5 lumbar vertebrae—separated by disks—plus the sacrum and coccyx, each formed from fused vertebrae. The major parts of each vertebra are the centrum and vertebral arch.

column. The foramen is continuous and protects the spinal cord; spinal fluid circulates within it. Spinal nerves pass from the cord through notches in the vertebral arch. A spiny projection extends from each side of the vertebral arch; a third projection in the middle of the vertebral arch may be seen or felt through the skin. Thoracic vertebrae have articulating surfaces for attachment of ribs. The bodies of the vertebrae are separated from each other by cartilaginous pads called intervertebral disks. The vertebrae are held together by strong ligaments, but the general design of the spinal column allows considerable flexibility. The spine is subject to injury, curvature, arthritis, infections, and slipped disks.

spinel [spuh-nel'] The magnesium aluminate mineral spinel ($MgAl_2O_4$) is used as a GEM when transparent and finely colored. Ruby spinel has been confused with RUBY, the Black Prince's Ruby in the British Imperial State Crown being a famous example. The different colors of the mineral, caused by impurities, include various reds, yellow, blue, green, brown, and black. Hardness is 8, luster is vitreous, and specific gravity is 3.5 to 4.1. Gem spinels occur as crystals and pebbles in placer deposits, where they accumulate because they resist weathering. Common spinel occurs in metamorphic rocks and as an accessory mineral of some basic igneous rocks.

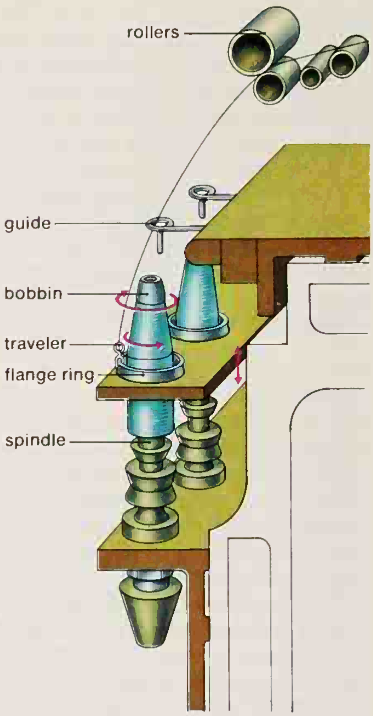
spinet [spin'-et] The spinet, along with the VIRGINAL, was one of a group of smaller keyboard instruments that was contemporary with the HARPSICHORD. They all have the same action; the strings are plucked by means of a quill or plectrum mounted in a jack. The spinet and virginal have about the same relationship to the harpsichord as the upright piano has to the grand. As is the case with the term *virginal*, *spinet* may refer to several different instruments.

In Italy the word *spinetta* was applied to all small instruments, whether they were rectangular or polygonal. In the Low Countries *spinet* was the name applied to a rectangular version with the keyboard left of center, and *muselar* described the same instrument with the keyboard right of center; they were also known as *virginals*. In France *épinette* was used for all small keyboard instruments.

spinning Spinning is the process by which cotton, wool, flax, and other short fibers are twisted together to produce a yarn or thread suitable for weaving into cloth, winding into rope or cable, or used in sewing. In hand spinning, the fibers are first cleaned and disentangled and then loosened by carding them. The fibers can then be drawn out and, with sufficient twist, will be locked together so firmly that they can no longer slide past each other, thus forming a strong yarn.

Until about 1300 yarn was spun on the spindle and whorl. A spindle is a rounded stick with tapered ends to which the fibers are attached and twisted; a whorl is a weight attached to the spindle that acts as a flywheel to keep the spindle rotating. The fibers were pulled by hand from a bundle of carded fibers tied to a stick called a distaff. The spindle, which hung from the fibers, twisted the fibers as it rotated downward, and spun a length of yarn as it pulled away from the fiber bundle. When the spindle reached the bottom of its descent, the spun yarn was unhitched from its tip and wound around the spindle body, and the spinning of an additional yarn length was begun.

The Spinning Wheel. The spinning wheel appeared in Europe in the 14th century. It consisted of a horizontally mounted spindle that was connected to a large, hand-driven wheel by a circular band. The spinner's left hand fed the fibers into the spindle from a distaff that was sometimes mounted on the frame of the wheel, and the right hand turned the wheel. When a length of fiber had



The ring frame, invented (1828) by John Thorp and based on Richard Arkwright's spinning frame, is used to spin cotton. The fibers are drawn through a series of rollers and a guide down to the traveler on the flange ring. The traveler, replacing the flyer, spins around the flange ring and guides the thread onto the bobbin, which is positioned on the spindle. The traveler and flange ring are located on a movable plate that rises and falls with each revolution of the spindle, distributing the tread evenly on the bobbin. The ring spinning method is the most common today.

been spun, the process stopped while the yarn coils on the tip of the spindle were cleared by reversing the spindle's rotation.

About 150 years later, a mechanical improvement was introduced. Called the Saxon wheel, it was operated by a foot pedal, leaving both hands free to manipulate the fibers. The yarn passed through a hole in the end of the spindle. Fixed to the spindle was a U-shaped flyer, one arm of which guided the spun yarn to the side of the spindle and onto a spool, or bobbin. As it circled the spindle, the flyer twisted the yarn, then wound it evenly around the bobbin. Spinning and winding-on were continuous.

Spinning Mechanization. The first of several developments during the 18th century, the invention (1733) of the flying shuttle by John KAY increased LOOM production so much that a yarn shortage resulted. In 1766, James HARGREAVES perfected his spinning jenny, which featured a series of spindles set in a row, enabling one operator to produce large quantities of yarn suitable for coarse-weave fabrics. In 1769, Sir Richard ARKWRIGHT patented the spinning frame, a machine that used a series of rotating rollers to draw out the fibers. This spinning frame, which could open, card, draw, rove, and spin cotton, became the prototype for the spinning machines used in the early stages of English textile industrialization. Samuel Crompton's mule, introduced in 1779, could spin any type of yarn, from fine to coarse, in one continuous operation and in great quantity. Much more efficient and productive than either the Hargreaves or Arkwright machines, the mule, eventually powered by steam, was used for more than 100 years.

The ring frame, invented (1828) by the American John Thorp, was based on Arkwright's spinning frame. Ring spinning allows for high spindle speeds and has become the most widely used spinning method today.

Spinoza, Baruch [spin-oh'-zuh, bah-rook'] Baruch (or Benedict) Spinoza, b. Amsterdam, Nov. 24, 1632, d. Feb. 21, 1677, was one of the most important philosophers of the European tradition of RATIONALISM.

Life. Spinoza was born into a family of Portuguese Jews who were refugees to Holland at the end of the 16th century. By the time he was 24 years old, Spinoza rejected traditional interpretations of Scripture and thus deviated from Jewish orthodoxy. In 1656 he was expelled from the synagogue at Amsterdam.

Supporting himself by grinding lenses for optical instruments, Spinoza stayed for a period of time in the vicinity of Amsterdam. In 1660 he went to Rijnsburg, near Leiden, where he began his correspondence with Henry Oldenburg, secretary of the Royal Society in London. In 1671 he moved to The Hague. In order not to compromise his freedom of thought and speech, he refused a chair at the University of Heidelberg two years later. He died of tuberculosis.

Philosophy. Spinoza uses much of Descartes's philosophical vocabulary and definitions. He owes to Descartes the idea of a mathematical method that distinguishes his main work, *Ethica ordine geometrico demonstrata* (Ethics Demonstrated in Geometrical Order), which was published posthumously.

Spinoza's *Ethics* is divided into five parts: "On God," "On the Nature and Origin of the Mind," "On the Nature and Origin of the Emotions," "On Human Bondage," and "On Human Liberty."

Each part follows a rigorous geometrical method, passing through definitions, axioms, and postulates to propositions, demonstrations, corollaries, scholia (biblical exigeses), and lemmata (intermediate theorems). The overall aim of the work is to lay out a program for "the perfection of human nature."

In part 1, Spinoza defines God as the only true cause and the unique substance, outside of which "no other substance can be given or even conceived." Although this one Divine Substance has an infinite number of attributes, humans can know only two: thought and extension. Concretely, this concept means that although ideas and bodies appear to be separate things in human experience, they are in fact only aspects of the one Divine Substance.

A basic axiom in the whole unfolding of Spinoza's system states the strict parallelism between the two lines of thought and extension: "The order and connection of ideas is the same as the order and connection of things." As this parallelism develops, a universal necessity is attached to it. Neither in the Divine Substance nor in its attributes or modes is there any room for contingency. What is termed Divine Freedom is simply the absence of external constraint. This determinism emerges in human nature as well; it is nothing more than ignorance of the true causes of an individual's action.

An early advocate of intellectual freedom, the 17th-century Dutch metaphysician Baruch Spinoza was formally expelled for heresy by the traditionalist Jewish community of Amsterdam in 1656. Thereafter, he supported his lifelong rationalist inquiries by working as a lens grinder, refusing any scholarly patronage.

In part 2 human existence is reduced to modes of thought and extension. The mind is a mode of thought, and as such it is "a part of the infinite intellect of God." The body is a mode of the Divine extension.

In part 3, Spinoza defines an *affect* as a modification by which the body's power to act is increased or diminished. Affects involve both thought and extension. Human beings are the "adequate cause" (even though ultimately God alone is a cause) of those affects which are actions and the inadequate cause of those which are passions.

In part 4 of the *Ethics*, Spinoza discusses the concept of "human bondage." A natural tendency exists for an individual's passive feelings, or passions, to take control of life and make that individual a slave. The only remedy is to convert passions into actions.

In part 5, Spinoza explains how action is achieved. To the extent that humans understand how everything, including their passion, is a necessary mode of a Divine attribute, they can gain an "adequate idea" of it. As they "clearly and distinctly" understand their passions, they gain power and become a more adequate cause of the passions. The latter become actions, and humans overcome their bondage.

The last stage of human liberation is seeing that "all bodily affections are referred to God." At this stage all passion is transformed into an action that is "the intellectual love of God." This process is the very perfection of human nature, in which humans intuit their oneness with God. It not only liberates and beatifies but also confers on them a kind of immortality.

spiny anteater Spiny anteaters, or echidnas, are egg-laying mammals making up the family Tachyglossidae, in the order Monotremata (see MONOTREME). They have compact, muscular bodies and short legs with broad feet and large claws that they use to dig up termites, ants, and worms. At least one species has electroreceptors in the tip of the snout that may be used to detect electrical signals given off by prey. The echidna's body is covered with coarse hair and barbless spines, and it has small ears, a stubby tail, and a long, toothless snout. The female lays a single egg, which is placed in a temporary pouch formed on her abdomen. The egg hatches in 7 to 10 days. The young feeds on thick, yellowish milk that flows from the mammary glands along several tufts of hair into the pouch. Young stay inside the pouch for 6 to 8 weeks.

The short-nosed echidna, genus *Tachyglossus*, ranges from Tasmania and Australia proper into New Guinea. It reaches about 50 cm (19.5 in) in length, plus tail, and 6.5 kg (14 lb) in weight. The long-nosed echidna, *Zaglossus*, is confined to New Guinea. It attains 66 cm (26 in) in length, plus tail, and 10 kg (22 lb) in weight.

spiny eel Spiny eels comprise about 50 species of fresh- and brackish-water eellike fishes living throughout the southern half of Africa and Asia. Not related to the true eels, they are placed in the family Mastacembelidae, order Mastacembeliformes. The elongate, compressed fishes reach about 80 cm (32 in) in length and bear 17 to 40 spines down the middle of the back. A soft dorsal, soft anal, and caudal fin are present. Spiny eels are adept at burying themselves in soft substrates and are popular aquarium fishes. All spiny-eel species are in the genus *Mastacembelus* except for the elephant trunk fish, *Macrognathus aculeatus*, whose fleshy trunklike projection, or snout, is somewhat longer than in other spiny eels.

spiny-headed worm Spiny-headed worms are unsegmented parasites that live as larvae in the hemocoels (blood spaces) of insects or crustaceans and as adults in the intestines of vertebrate animals. Their cylindrical body has a retractable proboscis ("head") armed with stiff hooks, which is the basis of their phylum name, Acanthocephala. The hooks serve to attach the worms to their hosts. The estimated number of species varies between 300 and 800, most of which rarely exceed 2.5 cm (1 in) in length; a few kinds may grow to about 50 cm (20 in) long.

spiral In mathematics, a spiral is a plane curve that is generated by the endpoint of a radius vector—a vector from a point of origin to the end point—as the radius vector increases (or decreases) in length while rotating about the origin. Many different spirals exist, depending on the exact relation between the length r of the radius vector and the angle θ that it makes with the positive x-axis. If the length is proportional to the angle, the equation in polar coordinates is $r = a\theta$, and the spiral is called an Archimedean spiral for its discoverer.

The logarithmic spiral ($r = e^{a\theta}$), discovered by Descartes, is a shape that occurs in nature in the septa of the nautilus and in pine cones (see FIBONACCI SEQUENCE). Other important types of spirals are the parabolic spiral ($r^2 = a^2\theta$) and the hyperbolic spirals ($r = a/\theta$).

spirea [spy-ree'-uh] Spireas are about 100 species of deciduous flowering shrubs of the genus *Spiraea* in the rose family, Rosaceae, and are native to the Northern Hemisphere. Their small, white or reddish flowers are typically borne in showy, flat-topped clusters. *S. vanhouttei*, a hybrid of *S. cantoniensis* and *S. trilobata* commonly sold as "bridal wreath," has smooth, arching stems covered with white flowers in late spring.

Spirit of St. Louis see LINDBERGH, CHARLES A.

spiritualism Spiritualism, in philosophy, is sometimes used as a synonym for IDEALISM. A far more common usage, however, refers to a system of religious beliefs centered on the presumption that communication with the dead, or spirits, is possible.

Attempts to evoke the spirits of the dead are recorded in ancient Near Eastern and Egyptian sources, and spiritualistic practices have a long history in India, where they are regarded as *bhuta* worship, or worship of the dead. Spiritualism in its modern sense, though, traces its origins to the activities of Margaret Fox and, to a lesser extent, her two sisters. Beginning in 1848 at their parents' farmhouse near Hydesville, N.Y., the Fox sisters were able to produce spirit "rappings" in answer to questions put to them. After moving to Rochester, N.Y., and receiving a wider audience, their fame spread to both sides of the Atlantic. By the mid-1850s they had inspired a host of imitators. Margaret Fox admitted later in life that she had produced rapping noises through manipulation of her joints.

A person who "channeled" communications between the earthly and spirit worlds was first referred to as a medium, although now such an individual is often called a channeler. The repertoire of the early mediums included table levitations, EXTRASENSORY PERCEPTION, speaking in a spirit's voice during trances, automatic writing, and the manifestation of apparitions and "ectoplasmic" matter. All such phenomena were attributed by the mediums to the agency of spirits. Support for spiritualism diminished as many 19th-century mediums were proven to be fakes. Because it was closely aligned with other NEW AGE beliefs, however, belief in spiritualism again became popular during the 1980s, particularly in the United States.

See also: PARAPSYCHOLOGY; THEOSOPHY.

spirituals Religious songs of African Americans, especially those songs first brought to public attention in the 19th century, are called spirituals. Inseparable from most aspects of Southern black life, they were associated with work, recreation, and religious gatherings. Their call-and-response pattern with unison singing clearly points to African tribal sources.

Part of the repertory of spirituals is made up of modified tunes that blacks learned at revivals and camp meetings, where they were enthusiastic, but segregated, participants. Early spirituals had in common the repetitions of text, the leader-and-chorus concept that made possible the creation of new songs without rehearsal or prior planning, unison singing, and strong rhythms. Among pieces that became widely known were "Roll, Jordan, Roll," "Go Down, Moses," and "Steal Away to Jesus."

With the establishment of schools for blacks after the Civil War, music instruction brought about the beginning of organized, rehearsed music-making in a style comparable to that of urban whites. The Fisk University Jubilee Singers and groups from Hampton Institute and Tuskegee Institute first brought spirituals to audiences outside the South. The harmonized arrangements they presented lost much of the unique character of the original pieces, but they popularized the idiom, which began to make its way into the repertories of white choral groups and into hymnals.

The spiritual has been generally replaced as a vital, growing expression by a type of GOSPEL MUSIC unique to African Americans.

spirochete [spy'-ruh-keet] Spirochetes, which are BACTERIA belonging to the order Spirochaetales, include species that cause a number of severe diseases in humans and lower animals, such as hemorrhagic JAUNDICE, RELAPSING FEVER, SYPHILIS, and yaws. Spirochetes are slender, spiral-shaped organisms that differ from eubacteria in that they do not possess rigid cell walls and are therefore flexible. These unicellular organisms vary in length from 2 to 500 microns. They propel themselves usually by spinning around the longitudinal axis of the body. A bundle of very fine fibrils, spirally wound around the organism, has been observed in several types of spirochetes; it appears that propulsion may be aided by contractions of this bundle. Spirochetes are ubiquitous, occurring in soil, in water, in decayed organic matter, and in and on animals and plants.

Spirogyra [spy-roh-jy'-ruh] The freshwater species of green ALGAE known as *Spirogyra*, or pond scum, commonly occurs as a floating, light-green mass on the surface of still lakes and ponds. It consists of unbranched filaments having cells that are joined together and form an extensive coil. Each cell contains a nucleus and a spiral-shaped chloroplast. *Spirogyra* can reproduce asexually by means of fragmentation and can reproduce sexually by conjugation. During conjugation two adjacent filaments form swellings on the sides of the cells in contact. These swellings enlarge and fuse to form a tubular connection known as a conjugation tube. One cell then migrates in amoeboid fashion through the tube and fuses with another cell, forming a zygote. The zygote develops a thick wall and, after a dormant period, may germinate and produce a new filament.

Spitfire Designed by Reginald Mitchell, the single-seat, low-wing Spitfire monoplane became the best-known fighter ever built. The first all-metal British fighter, it entered Royal Air Force service in 1938 and was the companion of the Hawker Hurricane in the Battle of Britain (1940). Initially, in the Mk. IA model, the Rolls-Royce Merlin engine was used, having power ratings from 1,030 hp upward, and the elliptical wings (spanning 11.33 m/ 36 ft 10 in) were armed with eight .303 Browning machine guns. Improvements on the Spitfire design culmi-

The British Spitfire, flown by the RAF in many versions, was the only Allied fighter in continuous production throughout World War II. The combat effectiveness of the Spitfire was a major factor in thwarting German air attacks during the Battle of Britain (1940).

nated in the Mk. 24 model (1946), and the Seafire, which was developed for use from aircraft carriers of the Fleet Air Arm. The Spitfire was also used to pioneer unarmed photographic reconnaissance.

Spitsbergen see SVALBARD

spittlebug Spittlebugs, family Cercipodae, are not true bugs; they are so named because they live as nymphs in a frothy, spittlelike mass that they secrete. They leave this spittle upon achieving adulthood and are active jumping insects called froghoppers because of their vague resemblance to tiny frogs. Most adults are 5–10 mm (0.2–0.4 in) in length. Spittlebugs feed by sucking the sap from plants; one species, *Philaenus spumarius*, often does considerable damage to such crops as clovers.

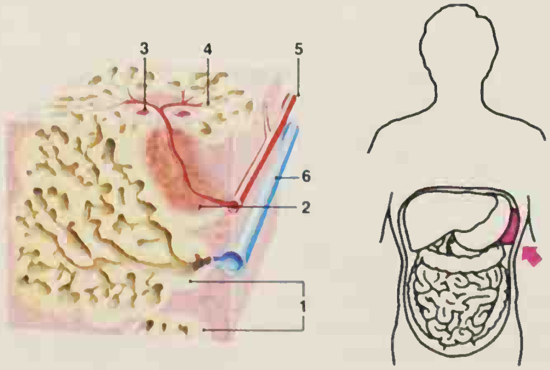
spitz [spits] The spitzes are a group of dogs characterized by a dense coat, a wedge-shaped head, erect ears, and a bushy tail carried curled over the back. They range in size from breeds such as the little pomeranian, through medium-sized forms such as the Norwegian elkhound, to large varieties such as the Japanese akita; the Belgian schipperke, which has a relatively short coat and is often tailless, is sometimes regarded as a modified spitz. Only a few of the spitz group are actually called spitzes: these include the German wolf spitz, the Finnish spitz, and the American spitz; the last, now more correctly known as the American eskimo, was once a well-known breed or type in North America. Broadly, the spitz group includes the northern sled dogs, such as the Alaskan malamute, as well as the more typical spitzes, such as the Dutch keeshond. Some authorities separate the northern dogs from the others on the basis of physiological and behavior differences, including the northern dogs' greater tolerance to cold and their tendency not to bark.

Spitz, Mark Mark Andrew Spitz, b. Modesto, Calif., Feb. 10, 1950, is the American swimmer who won a record seven gold medals at the 1972 Olympic Games. No athlete in any event had ever dominated a single Olympics as did Spitz. He gave no indication of greatness in the 1968 Olympics when he won a silver and a bronze medal. In 1972, however, he won the 100- and 200-m (109.4- and 218.7-yd) freestyle and butterfly events and was a member of the winning 4 × 100- and 4 × 200-m freestyle relay teams and the 4 × 100-m medley relay team. Spitz set 32 world and 38 U.S. swimming records during his career. He attempted a comeback in the early 1990s.

spleen The spleen, the largest organ of the LYMPHATIC SYSTEM, is closely associated with the circulatory system. It is located below the diaphragm, behind and to the left of the stomach. The spleen is a richly vascular organ and has a great number of lymphocytes and reticuloendothelial cells, necessary for filtration of cell waste products and worn-out red BLOOD cells and for production of antibodies and certain blood cells.

The organ comprises white pulp, red pulp, and marginal zones. The white pulp consists of periarterial lymphatic sheaths and lymph follicles. The lymphatic sheaths, loose meshes of tissue surrounding a central artery, are composed predominantly of small lymphocytes. Red pulp, which is rich in erythrocytes and granulocytes from the blood as well as lymphocytes and macrophages, consists of thin-walled sinuses and splenic cords (cords of Bilroth). Marginal zones receive terminal branches of central arteries and contain blood cells from the arterial vessels, macrophages, and lymphocytes. All animals, except for humans, have smooth muscle surrounding the spleen, which contracts and expels blood from the reservoir during periods of blood loss.

The spleen is an oval-shaped organ located on the left side of the abdominal cavity (right) *under the diaphragm. As a filter for the blood, the spleen removes damaged red blood cells and recycles the iron from the hemoglobin as well as filtering out bacteria and debris. It also acts as a reservoir for newly mature red blood cells and produces immunologically active white blood cells. As seen in cross section* (left), *the spleen is composed of white pulp* (1), *consisting of sheaths of lymphatic tissue, and red pulp* (2), *consisting of cords of cells and blood-filled venous sinuses. Lymphatic follicles* (3)*—enlargements of the lymphatic sheaths where lymphocytes are produced—are found at various locations. Small arterioles* (4) *branching from the trabecular arteries* (5) *carry blood through the white pulp into the red pulp; blood flows from the venous sinuses to the trabecular veins* (6) *and is transported from the spleen.*



The spleen has trabeculae that extend inward from its surrounding capsule and form an extensive network. Blood vessels, nerves, and lymphatic vessels enter the spleen at the hilum, an indented area on the surface, and course along the trabeculae. The blood vessels end in capillaries and open into the red pulp, and the blood then is collected by veins either slowly through splenic cords and sinuses and subsequently into larger veins or by way of more direct vascular shunts.

In adult humans the spleen functions as an immunologically active organ and as a filter for white and red blood cells. Lymphocytes as well as plasma cells are manufactured in the white pulp, and circulating antigens can be stored. Antibodies are also produced in the white pulp in response to antigens. The filtration system of the marginal zone and the red pulp allows macrophages to ingest cellular waste transported into the spleen by the blood. When the worn-out red blood cells are destroyed by the spleen, the iron is recycled to make new hemoglobin, and other products are converted into bilirubin, a pigment transported to the liver and later incorporated into bile. The red pulp is a reservoir for newly mature erythrocytes and blood platelets and, to a lesser extent, for lymphocytes and monocytes. In a developing fetus, the spleen is a major organ of blood production, but this function normally does not continue after birth.

Slight enlargement of the spleen is normal during and after digestion, and the size of the spleen in adults usually ranges from 100 to 250 g (3.5 to 8.3 oz). Abnormal enlargement, or splenomegaly, may occur in the course of a number of diseases, including various inherited disorders, diseases of the liver, cancer, and chronic infections such as malaria and tuberculosis. For some of these diseases, and in cases in which the spleen ruptures, surgical removal of the organ (splenectomy) may prove beneficial. In most instances, a splenectomy has no harmful aftereffects.

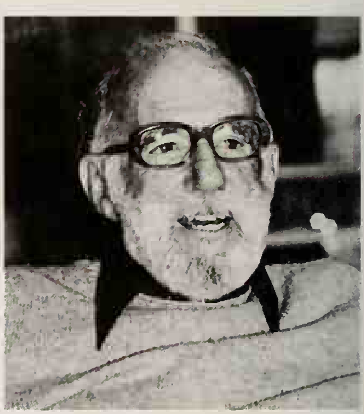
Split Split is the main city of Dalmatia, the western region in the Croatian republic of Yugoslavia, and the second largest port of the country. Located on the Adriatic Sea, about 260 km (162 mi) south of Zagreb, it has a population of 191,074 (1987 est.).

The well-preserved old town grew around Diocletian's Palace, where the Roman emperor retired in 305 and died in 313. The palace is one of the finest examples of Roman architecture. The modern Split spreads out around the palace and along the Adriatic shore. The city's two harbors were rebuilt after their destruction in World War II. The economy is based on shipping, shipbuilding, and the manufacturing of cement, plastics, and chemicals. Split is also a popular tourist resort.

Once known as Spalato, the site was colonized by the Romans in the 1st century AD and settled by Croats in about 639. During the 9th century Split was a major Byzantine city. It was later ruled by Venice (1420–1797). Except for a period of French control (1808–13), Split was dominated by Austria from 1797 until it became part of Yugoslavia in 1918.

split personality see PERSONALITY, MULTIPLE

Spock, Benjamin Dr. Benjamin McLane Spock, b. New Haven, Conn., May 2, 1903, was the first person to complete professional training as a pediatrician and a psychiatrist. Dr. Spock is famous both for his book on child care and for his leadership in the peace movement. *The Commonsense Book of Baby and Child Care* (1946) was a dramatic contrast to earlier child-care books that had favored rigid feeding schedules and had warned against showing a child too much affection. Spock's book was reassuring in its support of maternal tenderness. It answered practical questions not addressed by earlier works and (even though it was later accused of encouraging "permissiveness") encouraged parents to set standards and expectations for their children. The 40th-anniversary edition, now called *Dr. Spock's Baby and Child Care* (1985), has a completely updated medical-pediatric section written by the book's new coauthor, Dr. Michael B. Rothenberg.



Benjamin Spock greatly influenced child-rearing practices with The Commonsense Book of Baby and Child Care *(1946). Spock's association with antiwar movements during the 1960s culminated with his arrest and conviction (1968; overturned, 1969) for encouraging drafted men to resist conscription.*

spoils system see PATRONAGE

Spokan [spoh-kan'] The Spokan (or Spokane) are a North American Indian tribe of Interior Salish linguistic stock that traditionally occupied territory along the lower part of the Spokane River and its tributaries. Linguistically and culturally they differed little from such neighbors as the FLATHEAD and the OKANOGAN, and although they differed in language from the Sahaptin-speaking Wanapam and Palouse to their south, they were culturally similar to those tribes also. All these groups relied heavily for subsistence on salmon of several species that annually ascended the Columbia River and its tributaries in vast numbers. The Spokan living on or near their reservation in Washington State number 1,248 (1989 est.).

Spokane [spoh-kan'] Spokane is a city on the Spokane River in eastern Washington. The seat of Spokane

County, the city has a population of 177,196 (1990), and metropolitan Spokane County, 361,364. Located on a falls of the river, Spokane is the industrial, commercial, and transportation hub of the surrounding agricultural and mining region. Nearby are GRAND COULEE DAM and gold, silver, uranium, and copper fields. The leading industries are lumber, aluminum, and electrical equipment manufacturing and grain processing. The city is the seat of Gonzaga University (1887) and Whitworth College (1890).

A trading post of the North West Company was built on Spokane's site in 1810, and a settlement was established in 1871. The community called Spokane Falls was laid out in 1878 and was incorporated with the coming of the Northern Pacific Railway (1881). A fire in 1889 destroyed most of the city, but it was quickly rebuilt and renamed Spokane in 1891.

Spoleto Festival [spoh-let'-oh] The Spoleto Festival of the Two Worlds was begun in 1958 by the composer Gian Carlo MENOTTI, who resigned as artistic director in 1968 but remains the festival's guiding spirit. The first festival, lasting 3 weeks, offered performances of Verdi's *Macbeth,* conducted by Thomas Schippers and directed by Luchino Visconti, and O'Neill's *A Moon for the Misbegotten,* directed by José Quintero. Midday chamber concerts, underwritten by Alice Tully and directed by Charles Wadsworth, are a regular feature of the festival.

Since 1977 the festival has been literally "of two worlds" because of the establishment of the Spoleto Festival, U.S.A. in Charleston, S.C.

spondee see VERSIFICATION

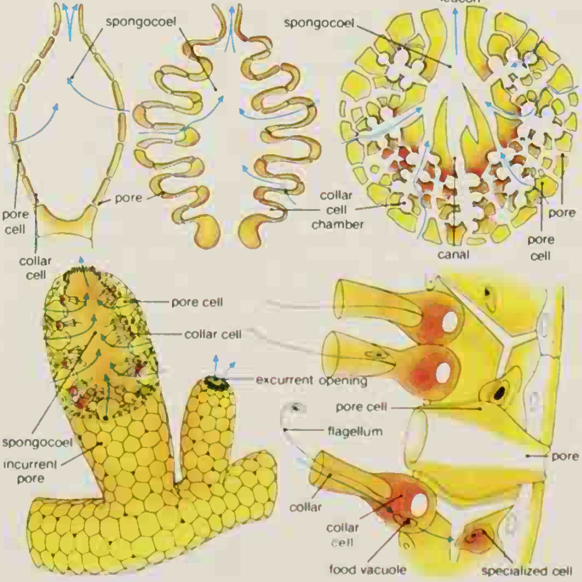
spondylitis [spahn-duh-ly'-tis] Spondylitis, a progressive disease of the spine, exists in two forms, ankylosing and tuberculous spondylitis. Ankylosing spondylitis is a disease of unknown cause, but with evidence of genetic transmission, occurring nine times more frequently in males than in females. It is a progressive form of ARTHRITIS and begins in the lower back, a common cause of pain in men in their twenties and thirties. The disease is characterized by degeneration of vertebral joints, calcium and bone deposition in associated ligaments, and inflammation of surrounding tissues. Vertebrae tend to fuse as a result of bone deposition between them (ankylosis). Associated compression of spinal nerves causes pain to radiate to other body areas. As the disease spreads up the spine, substantial stiffening and deformity can develop over a period of 10 years or more. Patients are treated with anti-inflammatory drugs for the symptoms and exercise programs for maintenance of correct posture.

Tuberculous spondylitis, or Pott's disease, is caused by tuberculosis in a vertebra, where the infection can destroy intervertebral disks and spread to adjacent vertebrae. Infectious agents other than tuberculosis can produce similar effects. Treatment consists of antibiotic therapy and sometimes surgical drainage of abscesses and fusion of affected vertebrae.

sponge Sponges comprise about 10,000 known species of aquatic, multicellular animals placed in 4 classes in the invertebrate phylum Porifera. Species of sponges, an ancient and flourishing group, occur worldwide at all depths of marine water; there are only about 20 species of freshwater sponges. Sponges live in colonies attached to the ocean floor or to other objects. The bath, or commercial, sponges were once commercially valuable, but they have for the most part been replaced by synthetic sponges. Sponges show striking powers of regeneration. Dissociated cells can quickly reaggregate to form a new, perfectly functional sponge.

Apparently, very early in their evolution sponges chanced upon a combination of activities and organization very different from those used by any other group of multicellular animals. Their entire organization is devoted to filtering microorganisms and dissolved organic matter from the water, but they do this without forming discrete tissues and organs. Instead, the whole mass of the sponge is penetrated by innumerable tubes and chambers (the aquiferous system) through which water flows as a result of the actions of groups of specialized cells, the choanocytes. These cells each bear a single flagellum surrounded by a tall collar of fine cytoplasmic projections

Sponges range in body structure from simple to highly complex. Their anatomy permits water (blue arrows) *to flow through, into, and out of the body. The most primitive type of sponge, an ascon, has smooth walls and no canals. A sycon's body is furrowed into simple canals, where water first passes before entering the spongocoel, or body cavity. A leucon, or advanced sponge, has numerous canals and cavities and performs more specialized functions than the simpler sponges.* (Lower left) *Water enters through pores and passes through collar cells, where microorganisms are trapped.* (Detail, lower right) *A food vacuole digests the microscopic animals before transporting nutrients to a specialized cell, which supplies the body with energy.*



(microvilli). The beating of the flagella of groups of choanocytes raises the water pressure inside the chambers whose walls are formed of choanocytes, which draws water in one direction through the sponge.

Water enters the aquiferous system through minute, incurrent pores (ostia) between the flattened cells forming the sponge's outer surface, passes through chambers and ducts of decreasing diameter, and enters the choanocyte chambers. Here small particles and large molecules are trapped on the collar microvilli and engulfed by the choanocytes, which ingest food particles and absorb oxygen. The filtered water passes out of the chambers via anastomosing ducts and cavities to one or a few large exhalant openings—the oscula—from which it is ejected with considerable velocity.

The sponges vary greatly in form and size, from sheets or irregular mats of tubes to arborescent, vase, and barrel shapes; lengths range from a few centimeters to several meters. Each form is designed to eject water a safe distance so it will not be inhaled again, because the expelled water is depleted of food and oxygen and contains waste products.

Between the cavities and tubes of the aquiferous system lie cells of several forms and functions surrounded by their products. Cells called amebocytes digest and store food and carry it to other cells. Pigmented granules in the amebocytes of some sponges give them a brilliant color. Archaeocytes are cells capable of dividing and of transforming into any of the other cell types, including skeletal cells.

All sponges have an organic skeleton in the form of strands of a special protein, spongin, which is similar to the collagen of other multicellular animals. Most sponges also have a mineral skeleton in the form of spicules of calcium carbonate (calcite) or silica. The spicules are woven together, with a "cement" of spongin, to form elaborate three-dimensional bracing structures. Their enormous range of size and form and pattern of integration is relied upon greatly for the classification and identification of sponges.

Members of the class Calcarea, a minority of sponges, have calcite spicules. Nearly all other sponges have silica spicules, either basically six-rayed (class Hexactinellida or Triaxonida) or basically four-rayed and single-rayed (class Demospongea). A few species (class Sclerospongea) have both calcite and silica components in their skeletons.

Although adult sponges are always immobile, most produce motile larvae. The larvae do not feed during this solely dispersal stage. Most sponges are hermaphroditic. Sperm enter sponges with the water current and are carried to the eggs by amebocytes or choanocytes, and fertilization occurs *in situ*. Larvae are also produced by asexual reproduction.

spontaneous combustion Spontaneous combustion, the self-ignition of certain substances, is initiated by slow oxidation. If the heat of the oxidation reaction cannot be dissipated, the temperature of the substance rises until it reaches its kindling point and bursts into flame. The chemical element phosphorus, for example, ignites in air so readily that it must be stored under water. Coal is also subject to spontaneous combustion and is generally stored in shallow piles to dissipate the heat.

Spontaneous combustion represents a safety hazard in the home and business. Rags impregnated with volatile substances such as oil, paint, or furniture polish are one such hazard unless destroyed, washed, or kept in a metal container with a tight-fitting metal lid. Hay stored in a barn also should be thoroughly dry, because heat is generated in moist hay by the oxidizing action of microorganisms. As the temperature rises, air takes over the oxidation process, increasing the temperature until ignition occurs.

See also: COMBUSTION.

spontaneous generation Spontaneous generation is the name of the theory that life develops spontaneously from nonliving matter. The belief arose in ancient times as a way of explaining why certain living creatures are commonly found in association with certain inanimate materials—for example, maggots on decaying meat, mice in garbage, and insects in damp hay. Scientific observation, particularly by Francesco Redi, had practically demolished the theory by the 18th century; bacteria, however, were still thought to arise spontaneously from the media in which they were found. This idea was finally disproved in the 1860s, when Louis PASTEUR demonstrated that bacteria would not appear in a nutrient solution if it were sterilized by boiling and if air subsequently entering the flask containing the solution were filtered to remove airborne bacteria.

Although it is now known that all present life on Earth is the result of the reproduction of preexisting life, many scientists accept a modified theory of spontaneous generation to explain the origin of life itself. The theory holds that billions of years ago life originated in the oceans as the result of spontaneous aggregations of dissolved organic molecules, which in turn arose from inorganic chemical reactions energized by ultraviolet light, electrical discharges, and heat.

Spoon River Anthology A collection of poems by Edgar Lee MASTERS, the *Spoon River Anthology* (1915) sensitively reveals the secret feelings and conflicts that have characterized the lives of the inhabitants of Spoon River, a small midwestern town. Masters tells these secrets through epitaphs that often contrast strikingly with the actual epitaphs on the townspeople's graves. Many of the epitaphs are interrelated, thus providing the histories of several families and revealing Spoon River's social structure.

spoonbill Spoonbills are any of several large wading birds, family Threskiornithidae, named for their broadly flattened bills. The colorful roseate spoonbill, *Ajaia ajaja*, is about 80 cm (32 in) long and ranges from Argentina to the U.S. Gulf Coast. The adult roseate is mostly pink, with traces of crimson on the shoulders and white on the neck and back. The spoonbill breeds in colonies, and the female lays two to three eggs. The white spoonbill, *Plata-*

The roseate spoonbill, a long-legged water bird, uses its broad bill to catch fish and shrimp in shallow waters. Once nearly exterminated by those hunting it for its fancy plumage, it is now protected by U.S. law, and its numbers have increased.

lea leucorodia, of the Old World acquires a bushy, ocher crest during the breeding season. Other species are found in Asia, Africa, and Australia.

spore Spores are nondividing cells, produced by many plants and some protozoans, that are either modified asexual reproductive cells or cells characteristically resistant to adverse environmental conditions. The reproductive spores of ferns or fungi, for example, are produced by vegetatively growing cells and serve the reproductive function by their dispersability. These spores may be wind-borne or may be carried by insects and, under the proper conditions, can germinate and give rise to another generation of growing and dividing cells.

Many types of microorganisms produce spores modified to survive a harsh environment. Many genera of bacteria form spores, and some have been intensively studied. The genera *Bacillus* and *Clostridium* develop an endospore that is one of the most resistant forms of life known; many can withstand boiling or freezing for long periods of time, desiccation and indefinite storage, various types of radiation, toxic chemicals, and physical disruption.

The mechanisms by which the spore so dramatically survives are not completely clear but are probably related to the lowered water content of the cell. Spores' resistance to such a variety of harsh environmental conditions creates an important practical problem in industrial situations where the continued sterility of a product is necessary. The food industry, for example, has long been concerned with such spore-forming organisms as *Clostridium botulinum*, the organism that produces the deadly botulism toxin.

Sporozoa [spohr-uh-zoh'-uh] The Sporozoa are a large subphylum of microscopic, one-celled animals (see PROTOZOA) that live as parasites inside various animals. Sporozoans are immotile and feed by absorbing nutrients from the host. Many are relatively harmless, but some cause serious diseases. Members of the genus *Plasmodium* are agents of MALARIA. Other sporozoans cause diseases in poultry, sheep, foxes, and other animals.

Sporozoans have a complicated life cycle, normally alternating between sexual and asexual stages of reproduction. All types of animals have sporozoan parasites, and each species is generally restricted to one or two host animals in which different stages of its life cycle may occur. If the sporozoans are not transferred from one type of host to the next, their life cycle cannot continue. Usually, in the asexual phase sporozoans can live only inside a specific vertebrate animal, whereas in the sexual phase they can live only in an invertebrate. In the case of *Plasmodium* the vertebrate host is a human, where the organisms live in the bloodstream, attacking the red blood cells. The invertebrate host is the *Anopheles* mosquito, which picks up the male and female gametocytes by biting an infected person. In the mosquito's body, gametocytes mature into gametes that fuse to form a zygote. Sexual division occurs, and the resulting cells, called sporozoites (spore stage), migrate to the mosquito's salivary glands. When the mosquito bites a human, the sporozoites are injected into the new host's bloodstream, and the cycle begins again.

sports, history of Sports, which can be broadly defined as physical exertion for recreation or in competition, date so far back that modern historians cannot determine with certainty what the first sport or sports were. A reasonable assumption is that sports began the first time a person used physical energy under recreational conditions. Such sport could well have been fishing or hunting for pleasure or merely engaging in a playful demonstration of physical prowess.

Modern sports, however, are often thoroughly organized, with complicated sets of rules; sophisticated equipment; precise timing, measuring, and scoring devices; spectators; and extensive coverage by various media. Much of the development in sports, no matter how old such physical pastimes are, has taken place in the past 2 centuries, and the preponderance of this growth in sports has occurred since about 1930.

Archaeological evidence indicates that the Sumerians practiced WRESTLING as a sport about 5,000 years ago. Wrestling was essentially a survival skill that required practice in order to perfect various holds and grips. That it became a sport was almost inevitable. The same may be said for fishing or hunting, which became sports the first time they were undertaken for fun rather than for self-preservation.

The ancient Olympic Games, first recorded in 776 BC, could be called the birth of organized sports. Although the ancient Olympic Games were recorded in writing, even those games have an undetermined origin that historians

An ancient Roman sculpture of two wrestlers suggests the antiquity of the sport. Wrestling was a major event of olympiads in ancient Greece. (Uffizi, Florence.)

believe may antedate 776 BC by at least two centuries.

When the Olympic Games were revived in AD 1896 (they had been abolished in AD 394), Olympic accomplishments were precisely recorded using tape measures, stop watches, photographs, and newspaper reports. In 1896 sports were on the verge of a true golden age, far surpassing anything since the Sumerians were believed to have wrestled for fun. Sports in the 20th century eventually became a lucrative business, often involving highly professional athletes playing at an increasingly competitive level. With industrial progress giving people more and more free time, sports came to be an important leisure activity.

The development of sports from the end of the ancient Olympics to the mass sports events of the 20th century was a slow process, however. The conquest of Greece by Rome almost brought to an end the early golden age of sports. The Romans, although initially scornful of sports, placated the Greeks by allowing them to continue their Olympic Games with the religious connotations of the games left intact. The Romans, in fact, later popularized sports of their own, such as gladiatorial battles and chariot racing, and built coliseums in which to stage the contests.

Interest in sports dwindled under the Christian dogmatism of the Middle Ages. By AD 1200, however, sports for entertainment and diversion reemerged on a small scale in some countries. The French, for instance, had a hockeylike game called *la soule*. Like many rough games of that era, *la soule* was suppressed (1369) by authorities. The interest that such early sports generated led to other sports that used a ball, such as TENNIS, which rose to popularity in the 1400s.

The rise of sports in general in England merely whetted people's appetites for more sports. Records show that an unorganized track-and-field competition was held in England in 1510. Mary, Queen of Scots, because of her own interest in GOLF, popularized the game during her reign (1542–67). Her son, James I (r. 1603–25) of England, lifted the ban on football (the ancestor of modern soccer) in 1603 and openly endorsed other organized sporting activities. Queen Anne (r. 1702–14) of England introduced the first sweepstakes in horse racing in 1714. Continental Europe also fostered many sports during this era that led to the surge of sports in the 1800s.

What differentiated pre-19th-century sports from those which followed was organization. During the 19th century many sports that were invented or had evolved from existing sports became highly organized. The first modern track-and-field meet was held in England in 1825. Oxford and Cambridge universities participated in the first intercollegiate athletic competition when they held a rowing match in 1829. Ten years later Cambridge students popularized an accidentally invented sport they called Rugby's game, the forerunner of other similar games. In the United States RUGBY evolved into a unique sport, American FOOTBALL, which was first played on an intercollegiate level in 1869 in a match between Rutgers and Princeton universities.

BASEBALL, which ultimately became a pastime in many countries, was first regularly played in the United States in 1845 (professionally in 1869); BASKETBALL, another sport with international appeal, was invented in Springfield, Mass., in 1891. Golf, tennis, and many other sports were organized for local, national, and even international competition. In 1892 the first championship BOXING match in which gloves were used was held between John L. SULLIVAN and James J. CORBETT.

Boxing and, later, American intercollegiate football and professional baseball attracted large crowds of people; the phenomenon of the spectator became an especially prominent feature of sports before World War II.

With the growth of sports organization and interest, governing bodies were established for sports ranging from the international Olympic Games down to local softball and bowling leagues. With increased coverage of sports events by newspapers and then radio and television, sports began to consume a larger percentage of people's free time than it had prior to the 20th century. Sports stars such as Muhammad ALI (boxing), Paavo NURMI (track), Babe RUTH (baseball), and Jim THORPE (track and field, football) became internationally recognized figures, renowned not only as great athletes but as personalities that inspired other athletes as well as the average person.

sports medicine Sports medicine is that branch of medical science which deals with the treatment and prevention of injuries incurred while participating in sports. The field also concerns the methodology of scientific research to determine the causes of sports injuries. In recent years physicians who specialize in treating one specific part of the anatomy—such as the knee, back, foot, or elbow—have compiled and exchanged information on their specialty and have also formed associations to promote the study of injury-prone parts of the body.

The athlete's entire body is subject to countless varieties of sports injuries. The nature of the injuries is attributable to the individual characteristics of the athlete as well as to the demands of the particular sport. A clear understanding of how these two factors interrelate is essential for prevention and treatment of sports injuries.

Classifications of Sports

Sports can be classified according to the physical and mental demands imposed on the participants. In addition, there are environmental demands such as playing conditions, equipment used, and the rigorousness of practice.

Sports can also be categorized according to the kinds of movement that an athlete must perform. There are six basic motions in sports: stance, walk, run, jump, kick, and throw. These basic motions have all been rigidly defined for scientific study. A sport may involve one, a combination, or all of these motions. Baseball, for example, is obviously a sport that uses the throwing motion a great deal, but so are basketball, swimming, and tennis. Although these sports may seem dissimilar, they each require that the athlete make a repetitive throwing motion. These sports will place heavy demands on the upper body of an athlete, demands that may overtax a particular part of the musculoskeletal system and lead to such problems as "pitcher's elbow," "tennis elbow," "basketball finger," or "swimmer's shoulder."

Types of Sports Injuries

Whereas doctors once recommended rest and inactivity as a cure for an injury, today many athletes continue to train and compete while undergoing corrective rehabilitation.

Tennis Elbow. Tennis elbow is an inflammation of the structures in and around the lateral epicondyle, the bony knob on the outer side of the elbow. In its typical form tennis elbow is caused by repetitive microtrauma to this area resulting from poor shock absorption on the serve and backhand stroke. This can be caused by improper equipment or poor technique but may also be associated with relative weakness of the extensors of the wrist and fingers that attach in the vicinity of the epicondyle. In fact, a person need not be a tennis player to suffer from tennis elbow. The injury may also arise from job-related activities such as hammering or repetitive lifting. Attempts to treat tennis elbow include technique and equipment changes to alter stress points, elastic bands and splints to change the tension in the extensor origins, and even exercises to strengthen the finger extensors.

Shoulder Injuries. Shoulder problems are common in the so-called throwing sports of tennis, baseball, and swimming. Practicing the overhand motion of the Australian crawl for four hours a day can be devastating to a shoulder with a tendency toward partial dislocation. Chronic shoulder ailments are developing at increasingly earlier ages in young swimmers and in tennis players practicing their serves.

Back Injuries. Lumbosacral spine, or lower back, problems are common in sports with a great deal of bending, such as ice hockey, and even more prevalent in heavily muscled, tight-jointed weight lifters. The keys to prevention of injuries are flexibility in the spine and posterior thigh muscles and strength in the abdominals and anterior thigh muscles. This balance of strength and flexibility acts to functionally unload the spine. Cervical spine, or neck, injuries are seen most frequently in such high-velocity contact sports as football and ice hockey. Prevention is largely a function of good equipment with strict enforcement of safety rules.

Leg and Ankle Injuries. The great increase in RUNNING AND JOGGING activities in recent years has resulted in an equal rise in leg injuries that were previously uncommon. Shin splints, stress fractures, and varieties of TENDONITIS often result from ill-advised or overexuberant running programs imposed on unprepared musculoskeletal systems. Because of the increased attention being paid to the foot in the wake of the running boom, great advances are being made in the diagnosis and treatment of these injuries. This development has been of particular benefit to dancers, who are among the most demanding of athletes on their feet and ankles.

Knee Injuries. The most widely publicized lower-body injuries are those involving the knee. Football, in particular, has done much to further knowledge of the complexities of the human knee's functioning in health and disease. Severe knee instability is potentially dangerous; the joint must be properly braced, and a program of strengthening exercises to overcome weaknesses must be undertaken prior to competition in order to minimize the possibility of a debilitating injury.

Participants in jumping sports, such as basketball and volleyball, are vulnerable to knee problems without violent contact. These problems usually appear in the patellofemoral (kneecap and thigh bone) articulation and are manifested predominantly as inferior pole patella (area just below the kneecap) tendonitis, or jumper's knee. Treatment may involve a program of exercises to strengthen supporting muscles, or if the knee is acutely injured, immobilization or surgery may be required. Among the most useful surgical tools for knee and other joint injuries is the arthroscope, actually a family of instruments making use of fiber optics and microsurgical techniques. With the arthroscope a physician can diagnose a joint injury and perform an operation through a tiny incision rather than conducting major surgery. This allows for less damage to soft tissue and muscle, speeding postoperative recovery.

Substance Use and Abuse

Along with new surgical techniques and therapeutic regimens have come methods and medications to mask pain and decrease inflammation. Used legitimately, these methods have shortened injury times and lengthened athletic careers. They have also, however, led to the concept of artificial improvement of athletic ability. Many artificial methods are now being employed to increase performance or to build muscle bulk. Most remain of unproven value. Anabolic steroids, for example, are widely used to build muscle bulk and increase strength. These drugs do contribute to muscle bulk, but they can have many harmful physical and psychological effects (see STEROID). A practice of unproven worth, called blood-doping, has been used in attempts to improve endurance in long-distance events. The procedure is performed in several ways and the blood is usually the athlete's own, removed weeks before to allow the body to replenish its stores. The aim is to transfuse more oxygen-carrying red blood cells into the body just prior to competition. Although rules against such practices exist for many competitions such as the Olympic Games and other international meets, regulations vary widely at more regional levels. Tests also exist for the presence of a wide range of dangerous drugs and other controlled substances.

SPOT (satellite) SPOT—Satellite pour l'Observation de la Terre—is a French commercial Earth-observation satellite. *SPOT 1* was launched aboard an ARIANE expendable rocket on Feb. 21, 1986. Orbiting 833 km (517 mi) above the Earth, SPOT utilizes CHARGE-COUPLED DEVICES to achieve photographic resolution down to 10 m (33 ft). At this range individual buildings are clearly distinguishable. SPOT's circumpolar orbit allows it to pass over every part of the Earth every 26 days. Because its orbit is also "Sun-synchronous," uniform lighting of the images is achieved. The current design lifetime of SPOT satellites is about three years, and improved replacement satellites are expected to be launched as needed. (See also SATELLITE, ARTIFICIAL.)

Spotswood, Alexander The British colonial administrator Alexander Spotswood, b. 1676, d. June 7, 1740, was royal governor of Virginia from June 23, 1710, until 1722. He secured passage of an act requiring the inspection of all tobacco for export; although important to Virginia's economic system, it was opposed by many provincial leaders and later repealed. Spotswood facilitated the establishment of settlements in the West and encouraged trade with the Indians. A staunch Tory and defender of his own prerogatives, he was often accused of highhandedness by members of both his governor's council and the House of Burgesses, but his term as governor was generally successful and stable.

Spotted Tail Spotted Tail, or Sinte Gleska, 1826?–1881, a leader of the Brule SIOUX of the Teton Dakota, vigorously defended the territory, rights, and customs of his people. After 1863 he led his band against the westward-moving white settlers. Despite his efforts the Sioux lost extensive territory. After gold was discovered (1873) in the BLACK HILLS, Spotted Tail went to the area at the request of the Dakota. During negotiations with treaty commissioners he opposed the removal of the Dakota to INDIAN TERRITORY, but he nevertheless signed the treaty, which opened the Black Hills and provided for mining and white occupancy. The government named him head chief of the Brule band and gave him the title and pay of a lieutenant in the U.S. Army. In 1877, Spotted Tail and his people settled on Rosebud Reservation in South Dakota.

Sprague, Frank Julian [sprayg] The American engineer Frank Julian Sprague, b. Milford, Conn., July 25, 1857, d. Oct. 25, 1934, was a prolific U.S. inventor. A U.S. Naval Academy graduate (1878), for a time (1883–84) he assisted Thomas Edison. In 1884 he formed the Sprague Electric Railway and Motor Company, the first manufacturer to produce industrial electric motors. In 1887, Sprague equipped the first modern trolley in the United States, at Richmond, Va., and thereafter helped construct more than 100 such railways in the United States and Europe. Other inventions included high-speed, automatic electric elevators and the AC induction smelting furnace. He made numerous innovations in the field of electric railway control, such as automatic signaling and braking devices.

sprain A sprain is an injury to a joint or its surrounding tissues caused by external forces moving the joint beyond its normal limits or moving it in an unnatural direction. In order of frequency, the most common sites of a sprain are the ankle, knee, wrist, elbow, and spine. The abnormalities commonly seen in a sprain are torn ligaments, tendons, muscles, or synovial membranes in the vicinity of the joint, and detached cartilage inside the joint. In some sprains inflammatory fluid collects within the joint. These conditions cause pain, swelling, and restricted movement. Sprains are usually treated by bandaging the area to limit movement while healing takes place. In some cases a syringe is used to withdraw fluid that has accumulated inside the joint.

sprat Sprat, *Sprattus sprattus*, are silvery, herringlike fishes in the family Clupeidae. They occur in large schools inshore during the winter in the North, Baltic, Mediterranean, and Black seas. Each of these areas has its own distinctive population of sprat. Sprat move offshore and spawn in both fall and spring months. At any given time, larger fishes occur farther offshore than smaller ones. By the third summer of life, at a length of 10 to 12 cm (4 to 5 in), sprat begin to spawn. The eggs are pelagic. Sprat reach a maximum of 17 cm (7 in) in length in 4 to 5 years in the North Sea. Sprat are canned, smoked, and salted for human consumption.

Spratly Islands The Spratly Islands (Chinese: Nansha; Vietnamese: Truong Sa), a small group of islets, coral reefs, and sandbars in the central South China Sea, served as a Japanese submarine base during World War II. Considered important because of their proximity to shipping lanes and the possible presence of oil and natural-gas deposits, the islands are claimed by the People's Republic of China, Malaysia, the Philippines, Vietnam, and the Chinese Nationalist regime on Taiwan; the last has maintained a marine battalion on the main island of Itu Aba since 1946. Mainland Chinese forces have ousted Vietnamese from several atolls in recent years, and Malaysia has oil rigs there. Japan renounced its claim in 1951.

spreadsheet A spreadsheet is a computer program (see COMPUTER PROGRAMMING) designed to facilitate the manipulation of data in the form of words, numbers, or graphical elements (see also COMPUTER SOFTWARE). The value of a spreadsheet lies in the way it automates processes. This saves time, for example, when a user wants to change a variable and the computer calculates the effect of the change on the entire program. Spreadsheets are popular tools in business, where they now speed up and simplify such procedures as budgeting.

spring (device) see SUSPENSION SYSTEM

spring (water) A spring is any natural surface discharge of groundwater. The location of most springs is controlled by a combination of surface topography and rock structure. In horizontal strata with a perched water table, springs will occur where a valley wall exposes the aquiclude. In folded and faulted strata where an aquiclude overlies an aquifer, artesian springs may occur (see ARTESIAN WELL). Many of the world's largest springs emerge in valleys that have been eroded downward to intersect water-filled caverns in limestone. The largest U.S. spring is Silver Springs in Florida, which averages 23,000 l (6,100 gal) per second. Spring-water temperatures vary from about the mean annual air temperature in the region of the spring to the boiling point of water (100° C/212° F). Most hot (geothermal) springs are heated by nearby volcanic activity, although some are heated by circulation of water to great depths.

The chemical quality of spring water ranges from almost pure water to brine (saturated with salt). Springs having water containing more than about 2 grams of dissolved solids per liter (0.267 oz/gal) are called mineral springs. Gases may be dissolved in the water; carbon dioxide can produce a natural soda water, and hydrogen sulfide gives spring water a characteristic sulfurous odor.

springbok The springbok, or springbuck, *Antidorcas marsupialis*, in the family Bovidae, is a gazellelike antelope noted for its ability to jump as high as 3.5 m (11 ft) when startled, hence its name. It is about 135 cm (5 ft) long, stands nearly 86.4 cm (34 in) at the shoulder, and weighs about 35 kg (78 lb). Both sexes have black, ringed horns. Found in South Africa, where it has been largely exterminated, the springbok is protected in national parks.

The springbok is a high-jumping antelope native to South Africa. Once found in herds of 1 million or more, its numbers are now depleted, and it is found mainly in zoos and parks.

springer spaniel see ENGLISH SPRINGER SPANIEL; WELSH SPRINGER SPANIEL

Springfield (Illinois) Springfield, the capital of Illinois and seat of Sangamon County, is located in the central part of the state on the Sangamon River. The city has a population of 105,227 (1990), and the metropolitan area, 189,550, forming an industrial and business community in the midst of a rich agricultural and coal region. A historic city, Springfield was the home of Abraham Lincoln from 1837 to 1861 and is hence a tourist site. The Lincoln Tomb State Memorial is the burial place of Lincoln, his wife, and three of their four sons. The Lincoln Home National Historic Site is a restoration of the house where Lincoln lived from 1844 to 1861. Lincoln made his first "House Divided" speech at the Old State Capitol there, and the state historical library has an outstanding collection of Lincolniana. The city was also the home of the poet Vachel Lindsay and hosts the annual Illinois State Fair.

Settled in 1818 by Elisha Kelly and laid out in 1822, the city was named for Spring Creek and developed as a farm distribution center. In 1837, Lincoln was instrumental in having the capital moved there from Vandalia.

Springfield (Massachusetts) Springfield, the seat of Hampden County in southwestern Massachusetts, lies along the Connecticut River. The population is 156,983 (1990). Springfield is the commercial center of western Massachusetts and produces machinery, appliances, tools, printed matter, and the famous Springfield and Garand firearms. Cultural institutions include several museums, a symphony orchestra, and four colleges. The Naismith Basketball Hall of Fame is located there.

Settled in 1636 by William Pynchon, the city was incorporated in 1641. It was burned during King Philip's War in 1675 but was soon rebuilt. The scene of SHAYS'S REBELLION (1786–87) and home of the U.S. Armory (1794–1968), the city was also a part of the Underground Railroad before the abolition of slavery. The abolitionist John Brown had his wool business in Springfield, and the Duryea brothers started the first U.S. automobile company there in 1895.

Springfield (Missouri) Springfield, a city in southwestern Missouri at the northern edge of the Ozark Mountains, is the seat of Greene County. The city's population is 104,494 (1990), and that of the metropolitan area, 240,593. Located in a poultry and dairy region, Springfield has an economy based on agriculture and the manufacture of iron and steel products, clothing, and lumber products. Three colleges are there.

Settled about 1829, the city benefited from its location on several routes used for westward migration. Confederate forces held Springfield after the Battle of Wilson's Creek in August 1861, but Union troops recaptured it in February 1862.

Springfield (Ohio) Springfield (1990 pop., 70,487), the seat of Clark County, is a city in west central Ohio about 40 km (25 mi) northeast of Dayton. The center of a hog-farming and winter-wheat belt, the city manufactures agricultural tools, electrical products, automobile parts, and trucks. Wittenberg University (1845) is located there. Settled in 1799, Springfield grew when the National Road reached it in 1838.

springhare The springhare, or Cape jumping hare, of the genus *Pedetes*, is a large rodent, not a true hare, and is the sole member of the family Pedetidae. It has short front legs and long, powerful hind legs and a bushy tail as long as its body, which measures about 40 cm (16 in) in length. The African rodent weighs about 3.5 kg (8 lb). Its coat is soft and tawny to reddish brown with white underparts. It digs burrows in sandy soil and, usually at night, consumes plants and insects.

Springsteen, Bruce Rock 'n' roll singer Bruce Springsteen, b. Freehold, N.J., Sept. 23, 1949, achieved phenomenal popularity with his album *Born in the U.S.A.* (1984), which lamented the problems of the Vietnam veteran. Springsteen began his climb to stardom with *Born to Run* in 1975. He reached superstardom through songs that explored the American experience and reflected a populist affinity with the working class. His other albums, most of which have received critical praise, include *Darkness on the Edge of Town* (1978), *The River* (1980), *Nebraska* (1982), and *Bruce Springsteen and the E Street Band Live/1975–1985* (1986).

springtail Springtails (order Collembola) are minute, wingless, primitive INSECTS about 5 to 6 mm (0.20 to 0.24 in) long that jump by means of a taillike structure (furcula), which is folded forward under the abdomen when not in use. Although abundant, they are seldom noticed because they live mainly under bark, in leaf litter, or in the soil. Coloration is varied, and some are patterned or mottled. A tubelike structure, the collophore, is believed to aid in water uptake.

Spruance, Raymond Ames Raymond Ames Spruance, b. Baltimore, Md., Jan. 3, 1886, d. Dec. 13, 1969, was a U.S. naval commander in World War II. An instructor at the U.S. Naval War College before the war, Spruance was a rear admiral when hostilities with Japan broke out in 1941. He joined the U.S. Pacific fleet under Adm. Chester W. Nimitz and distinguished himself in the Battle of Midway (1942). As commander of the Central Pacific Area, he directed naval forces in the successful assaults on the Japanese-held Gilbert Islands in 1943, on the Marshall Islands and Saipan in 1944, and on Iwo Jima and Okinawa in 1945. Made a full admiral in 1944, Spruance succeeded Nimitz as commander of the Pacific fleet (November 1945 to February 1946). He later served as president of the Naval War College (1946–48) and as U.S. ambassador to the Philippines (1952–55).

spruce Spruces, genus *Picea*, comprise about 50 species of evergreen conifers in the pine family, Pinaceae. They are widely distributed in the coniferous forests of the cooler north temperate and subarctic regions, particularly in China. Spruces extend as far south as the high mountains of northern Mexico, southern Europe, Anatolia, the Himalayas, and Taiwan. Seven species are found in the United States and are important in forestry.

Spruce trees are characterized by their pyramidal form. The four-angled needles last for up to 10 years and are borne on peglike stalks, which remain on older twigs. Egg-shaped cones are produced mainly in the upper crown of the tree. Many spruces reach heights of about 60 m (200 ft). The black spruce, *P. mariana*, is an abundant conifer of North America. One of the most important European timber trees, *P. abies*, the Norway spruce, has drooping foliage. Spruce wood is used mainly for making pulp and paper.

The white spruce, a North American conifer, has bluish green leaves and brown cones that grow to 5 cm (2 in).

spurge Spurge is the common name for the more than 1,500 species of the plant genus *Euphorbia* of the spurge family, Euphorbiaceae. These plants are characterized by their milky sap and by the arrangement of the flowers: one female flower surrounded by several male flowers.

Spurges occur in tropical and warm-temperate regions and include annual and perennial herbs, shrubs, trees, and succulents. Among them are crown of thorns, *E. splendens*, native to Madagascar; IPECAC spurge, *E. ipecacuanhae*, of the eastern United States; POINSETTIA, *E. pulcherrima*, of Mexico; scarlet-plume, *E. fulgens*, of Mexico; and snow-on-the-mountain, *E. marginata*, of the midwestern United States.

Sputnik Sputnik was the project name for three artificial satellites (*sputnik* means "traveling companion" in Russian) launched by the USSR in 1957 and 1958. They weighed, in order, 84, 519, and 1,351 kg (184, 1,140, and 2,980 lb). Their scientific purpose was primarily to investigate outer space and to discover if living organisms could survive space conditions. They also played a political role, however. Their launching marked the opening of the "space race" between the United States and the Soviet Union.

The Sputniks came as a tremendous shock to the West, which had up to then tended to downgrade Soviet technical capability. In hindsight, the Sputniks should not have been such a surprise, because Moscow had been releasing several explicit communiques about Soviet intentions, announcements that were dismissed as propaganda in the West. Reactions in the United States and Europe, which in some cases bordered on hysteria, initiated the American drive to send astronauts to the Moon (see SPACE EXPLORATION).

Sputnik 1 was launched from the BAIKONUR COSMODROME on Oct. 4, 1957. It was simply a test payload containing a radio beacon and a thermometer, and had been referred to by its designers as the "ES" (elementary satellite). A month later, on November 3, a half-ton payload carrying a dog was put into orbit by the same type of rocket. The dog, called Laika, was kept alive for 10 days, proving that life could survive prolonged weightlessness and other unknown conditions of space. *Sputnik 3*, launched on May 15, 1958, weighed almost a ton and a half. A wide array of scientific apparatus was reportedly on board to measure space radiation.

Seven other spacecraft were given Sputnik designations; they functioned either as prototypes for the VOSTOK manned spacecraft or as platforms from which probes to the planet Venus were launched (see VENERA).

Spyri, Johanna [shpee'-re] The Swiss author Johanna Heusser Spyri, b. June 12, 1827, d. July 7, 1901, wrote the classic children's story HEIDI (2 vols., 1880–81; Eng. trans., 1884). She was married to a lawyer and lived in Zurich. Other children's books besides *Heidi* include *Heimatlos* (1881) and *Gritli* (1882). The particular charm of *Heidi*, which has been translated into many languages, derives from Spyri's gentle humor and her ability to enter into the thoughts and emotions of a young orphaned child.

Squanto [skwahn'-toh] Squanto, *c.*1580–1622, a Pawtuxet Indian later associated with the WAMPANOAG after his tribe was decimated by plague, was seized (1614) by a ship's captain and taken to Spain as a slave. He went from there to England and finally back (1619) to North America, where he was employed by the governor of Newfoundland. Squanto was later brought to Plymouth, where he taught the colonists to improve their crops by using fish fertilizer, but it has been questioned whether this was an Indian method or something Squanto had learned abroad. He served as interpreter at the 1621 treaty between the colonists and MASSASOIT. Soon after, he died of a disease that he had contracted while guiding Gov. William BRADFORD's expedition across Cape Cod.

square In geometry, a square is a four-sided plane figure (a QUADRILATERAL) that has four equal sides of length l (making it a *rhombus*) as well as four equal (right) angles (making it also a RECTANGLE). Its area is $A = l^2$. In algebra, the square of a quantity is the second power of that quantity. For example, the square of 4 is $4 \times 4 = 4^2 = 16$, and $(a + b)^2 = (a + b)(a + b) = a^2 + 2ab + b^2$.

square dance Any American FOLK DANCE that requires the participation of many couples is called a square dance, whether those couples are arranged in a square (square set or quadrille), in two facing lines (longway set or contra dance), or in a circle (running set). A single couple fulfills the requirements of a round dance, such as the waltz or polka. Square dancing also identifies the only folk dance whose form is determined neither by tradition nor by the dancers themselves, but by a caller, a nondancer who names each dance's figures extemporaneously, combining established patterns (chains, stars, cloverleafs) with the caller's own inventions. Dancing for informal recreation, colonial settlers tailored English folk dances to fit any space and any number of untrained participants, and relied on a fiddle, fife, and drum, or regular handclapping, called "ratting," for music, usually in 2/4 or 6/8 time. Many regional variations and preferences developed, but only the square set traveled west with the pioneers. During the 1930s, public interest brought square-dance exhibitions into American cities. Urban and rural folk-dance organizations now teach and preserve the original forms.

square root The square root of any number is the number whose product with itself is the original number. For example, the square root of 9 is 3, the square root of 16 is 4, and the square root of 121 is 11. Because it is also true that $(-3) \times (-3) = 9$, $(-4) \times (-4) = 16$, and $(-11) \times (-11) = 121$, every positive number has both a positive square root (called the principal square root or just the square root) and a negative square root. The square root of a number can be denoted either by using a fractional exponent, such as $9^{1/2}$, or by using the symbol $\sqrt{}$, called a radical sign (see RADICAL, mathematics). Thus, $9^{1/2} = \sqrt{9} = 3$.

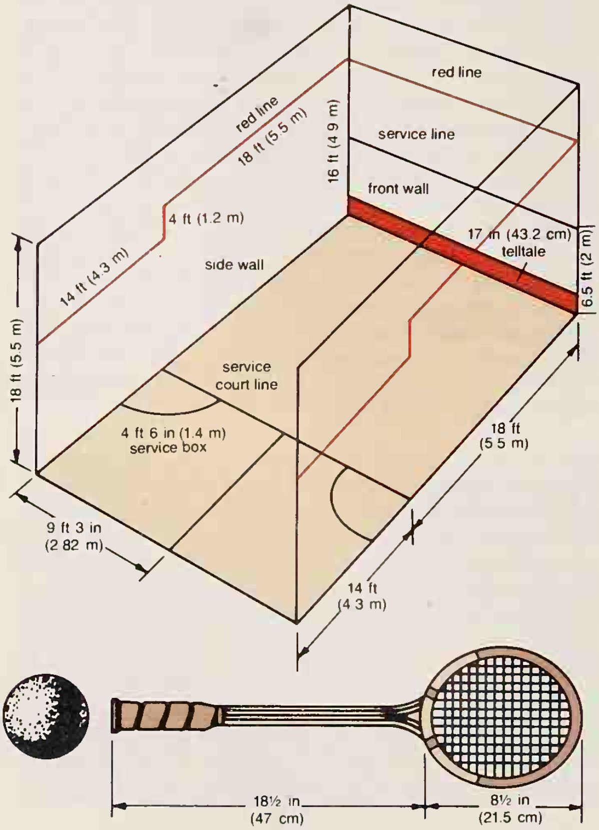
The square roots of most positive numbers are IRRATIONAL NUMBERS, because in most cases they cannot be represented exactly by a fraction or a decimal. They can, however, be approximated to whatever accuracy is desired. The number zero has only one square root—itself. The square root of any negative number is not a real number and is said to be imaginary (see COMPLEX NUMBER).

See also: ROOT (mathematics).

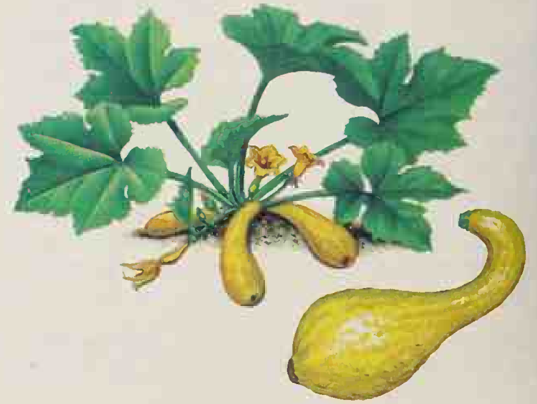
squash (game) Squash, or squash racquets, is an indoor racquet-and-ball game that is similar to handball. Two players, or four players in doubles, use racquets with small, round heads and thin necks to take alternate turns hitting a small, black, rubber ball against the front wall of a special court. Squash tennis is a variant of the basic game; it is played on the same court but uses a livelier ball and a heavier racquet.

The singles court is 32 ft (9.8 m) long and 18.5 ft (5.6 m) wide; the doubles court is 45 ft (13.7 m) long and 25 ft (7.6 m) wide. The front wall has a 16-ft-high (4.9-m) play line across the width and a 20-ft-high (6-m) play line for doubles. On the floor there are two service areas in the shape of quarter circles behind the "service-court line." The hollow ball has a diameter of 1.75 in (4.4 cm) and weighs about 1 oz (28 g).

To play, the server puts the ball in play while having one foot in the service area. The serve must hit above the service line on the front wall and rebound so that it hits the floor beyond the service-court line in the opposite half of the court. The server scores points until the service is lost. Service is lost when the server fails to hit the ball before it bounces twice, when the ball hits the "telltale" (a metal strip at the bottom of the front wall), or when the server sends the ball above the play line. A game ends at 15 points; the margin of victory must be at least 2 points, however, and play continues until that rule is satisfied. The player who wins three games (out of five) wins the match.


Squash, a sport that originated in England about 1850, is played on an indoor court (top) *with a long, narrow racket* (bottom right) *and a hard rubber ball* (bottom left) *slightly larger than a golf ball. Squash may be played by two or four people.*

squash (vegetable) Squash is any of several species of annual plants of the genus *Cucurbita* in the gourd family, Cucurbitaceae. The name is derived from an American Indian word. The plants are believed to have originated in South America, but their cultivation had spread throughout the Americas by the time the first Europeans arrived. Squashes are categorized as either summer or winter varieties. Most summer varieties are classified as *C. pepo* and bear relatively small fruits that are eaten while immature. The fruits can sometimes be picked within 50 days of seed planting. Popular varieties of summer squash are zucchini, yellow crookneck, and white bush scallop. Winter varieties of squash generally fall into the *C. maxima* classification and tend to be more nutritious than the summer varieties. Because the winter squashes are eaten when mature, their growing season usually requires 100 or more days. The mature fruit of the winter squash has a tough outer skin and can be stored at moderate temperatures (12°–15° C/54°–59° F) for several months. Hubbard, butternut, and acorn are winter varieties.


Crookneck squash is a yellow summer variety valued for its delicate flavor; it is eaten in casseroles and as a side dish.

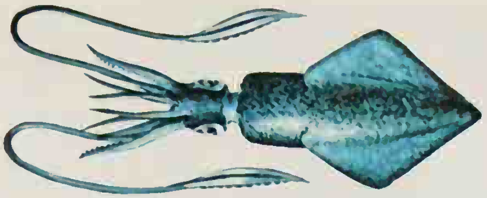
squatter A squatter is a person who settles on property without legal authorization and without paying rent. In the 19th century in Australia and the United States squatters settled on public land either to farm it or as a form of financial speculation. The U.S. PREEMPTION ACT of 1841 allowed squatters to buy land they had settled; in Australia the government issued leases to squatters in the 1840s. In the mid-20th century the population explosion in many Third World countries resulted in the establishment of "squatter colonies" around large cities.

squatter sovereignty see POPULAR SOVEREIGNTY

squid Squid is the common name for a group of carnivorous marine MOLLUSKS in the class Cephalopoda, phylum Mollusca. Other members of the class include the octopus, cuttlefish, and chambered nautilus. The common squid is often found in shoals off the eastern coast of the United States.

Squids have elongated, slender bodies with triangular caudal fins. The head-foot region is modified into five pairs of arms, or tentacles, with rows of suckers. The tentacles extend outward from, and surround, the mouth. Four pairs of tentacles are of about equal length and are used to steer in swimming. One pair is somewhat longer and retractile and is used to capture prey. The head of the squid possesses a funnel from which exhalant water-jets from the mantle cavity are shot, thus providing a means of rapid locomotion. The characteristic molluscan shell has been reduced to a horny plate buried under the mantle.

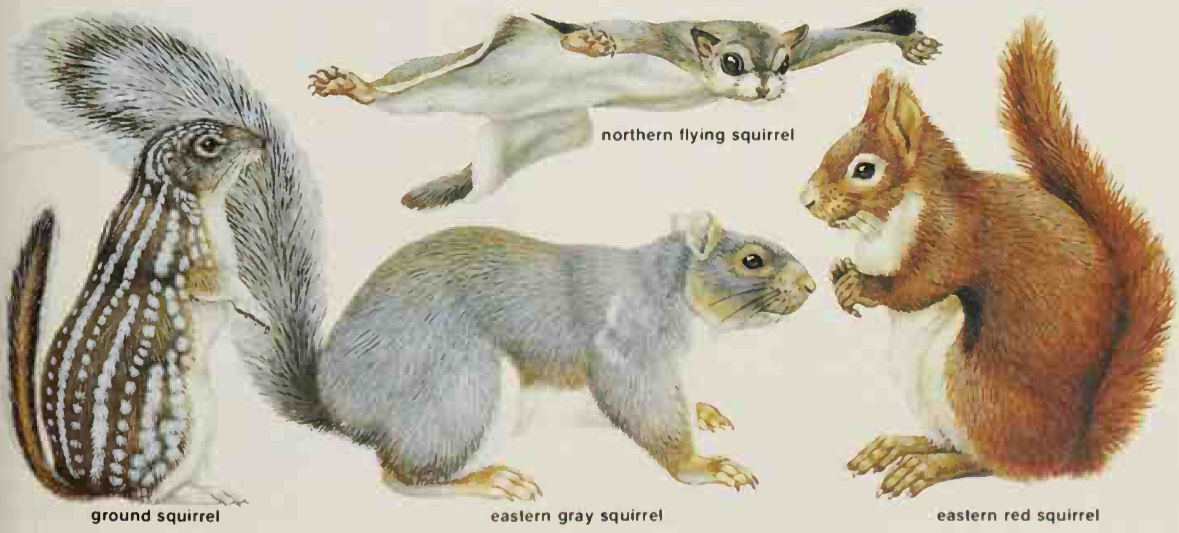
Squids have internal cartilaginous support and a cartilaginous braincase. They have a well-developed nervous system and large, image-forming eyes. They breathe through gills. Because the respiratory-system pigment is a copper compound, squids are blue-blooded.


The squid, a marine mollusk related to the octopus, moves by shooting water from its body, propelling itself backward. It can hide from an enemy by squirting an inky, water-clouding fluid.

Squids are able to change color rapidly by contracting and expanding pigment granules, called chromatophores, in the integument. Squids also contain an ink sac, the contents of which can be released to hide the animals' retreat when irritated or challenged. Most squids are small, usually less than 30 cm (1 ft) in length, but giant squids of the genus *Architeuthis* can reach up to 15.2 m (50 ft) in length, including tentacles, and weigh two tons. Squid is a popular food in the Orient and the Mediterranean region.

squirrel A squirrel is any member of the rodent family Sciuridae—with the exception of the marmots, genus *Marmota*; prairie dogs, *Cynomys*; and chipmunks, *Eutamias* and *Tamias*—and typically has a slender body and a long, bushy tail. The name is more commonly used to

The northern flying squirrel glides from tree to tree, storing its food supply in many different locations. The 13-lined ground squirrel lives in burrows and characteristically sits or stands on its hind legs to look around. The American, or eastern, gray squirrel is a familiar inhabitant of city parks, suburban areas, and woodlands. The eastern red squirrel, one of the most vocal of all squirrels, stores large caches of pine and spruce cones for its winter food supply.



refer to those forms which live in trees, although it is equally suited to terrestrial types. It is also used for arboreal African rodents of the family Anomaluridae, which are known as scaly-tailed squirrels.

The family Sciuridae contains two subfamilies, the Sciurinae (the tree and ground squirrels), with about 225 species, and the Petauristinae (the FLYING SQUIRRELS), with about 35 species. Squirrels are distributed throughout the world except for the Australian region, Madagascar, southern South America, and certain desert regions.

Squirrels vary in size from such tiny tropical forms as the pygmy squirrels, *Myosciurus*, of Africa, which are about 130 mm (5 in) in length including the tail, to the giant squirrels, *Ratufa*, of Asia, which may attain 91 cm (36 in). The tree and ground squirrels are typically diurnal; the flying squirrels, nocturnal. Squirrels eat primarily green vegetation, seeds, nuts, berries, fruits, and insects.

The American eastern gray squirrel, *Sciurus carolinensis*, typical of the tree squirrels, is native to the forests of the eastern half of the United States. Introduced into the United Kingdom, it has displaced the smaller native red squirrel, *S. vulgaris*, in many regions. Gray squirrels normally nest in tree hollows; they may also construct leaf nests, which are used mainly as feeding shelters. They may breed in midwinter and again in late spring. Gestation is about 44 days, with usually two to four young per litter.

Ground squirrels are similar in appearance to tree squirrels. They typically inhabit open or brushy regions, with some species occurring in tundra or desert. Most are burrowers, and those living in colder climates hibernate, whereas others, in hot, dry areas, may estivate.

squirrelfish Squirrelfishes are primitive spiny-rayed teleosts, or bony fishes. The 9 genera and about 70 species—some of which are also called soldierfishes—comprise the family Holocentridae in the order Beryciformes. Usually found in tropical marine waters around reefs, squirrelfishes typically have large eyes, sharp scales, and spines at the leading edges of their fins. Most are brightly colored, and the largest species reaches a length of about 0.6 m (2 ft). Members of the genus *Myripristis* are fished for food.

Sri Lanka [sree lahng'-kah] Sri Lanka is an island republic of Asia, lying in the Indian Ocean off the southern tip of India, from which it is separated by the Gulf of Mannar and Palk Strait. Formerly named Ceylon, it gained independence from Britain in 1948 and was renamed Sri Lanka ("beautiful island") in 1972.

Land and People

A mountain mass reaching a height of 2,524 m (8,281 ft) at Mount Pidurutalagala, the highest point in the country, marks the south central region of Sri Lanka. More than 80% of the country lies at elevations below 300 m (1,000 ft), and in all but the southwestern region the extensive coastal lowlands are dotted with lagoons. Numer-

AT A GLANCE

DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

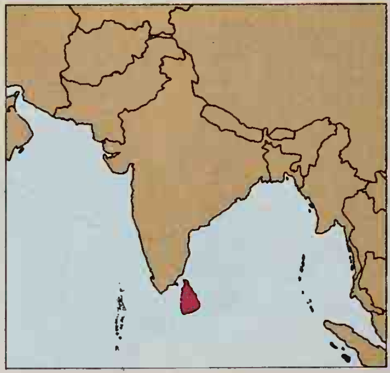
Land: Area: 65,610 km^2 (25,332 mi^2). Capital and largest city: Colombo (1988 est. pop., 609,000).

People: Population (1990 est.): 17,196,346. Density: 262 persons per km^2 (679 per mi^2). Distribution (1989 est.): 22% urban, 78% rural. Official languages: Sinhalese, Tamil, English. Major religions: Buddhism, Hinduism.

Government: Type: republic. Legislature: Parliament. Political subdivisions: 8 provinces.

Economy: GNP (1989): $7.01 billion; $417 per capita. Labor distribution (1990): agriculture—47%; mining and manufacturing—13%; commerce and services—28%; government and public authorities—8%. Foreign trade (1989): imports—$2.24 billion; exports—$1.56 billion. Currency: 1 Sri Lanka rupee = 100 cents.

Education and Health: Literacy (1985): 87% of adult population. Universities (1986): 9. Hospital beds (1987): 45,776. Physicians (1987): 2,341. Life expectancy (1990): women—72; men—68. Infant mortality (1990): 31 per 1,000 live births.



ous small rivers flow from the central heights.

Sri Lanka lies just north of the equator, in the monsoon belt of the Indian Ocean. About 1,016 mm (40 in) of rain falls in the northern lowlands, whereas the precipitation that occurs in the west and in the highlands reaches 5,080 mm (200 in) annually. Temperatures average 28° C (82° F) in the lowlands throughout the year.

Vegetation ranges from the evergreen forests of the wet highlands to scrub and cactuslike growth in the drier areas. Wildlife includes elephants, leopards, and bears, as well as many species of monkeys and snakes.

Sri Lanka is not rich in minerals, although it does have some iron ore, graphite, and gems such as sapphires and rubies. The extensive timberlands do not satisfy domestic needs. Fish are abundant offshore. A massive project, largely completed by 1986, diverts the Mahweli-ganga River to provide water for irrigation and hydroelectricity.

Except for a small number of aboriginal Vedda, almost all Sri Lankans are the descendants of migrants from India. The two major groups of Indian immigrants differ ethnically, linguistically, and in religion. The SINHALESE, 74% of the population, speak Sinhalese and are Buddhists. The TAMIL (18%) speak their own language and are Hindus. Smaller numbers of Tamil-speaking Muslims or Moors (7%), Burghers of Dutch descent, Eurasians, Malays, and Europeans make up the remainder. The Sinhalese and the Tamils observe CASTE distinctions, which are often important in politics. Sinhalese was the sole official language from 1956 to 1987, when English and Tamil were also recognized as official.

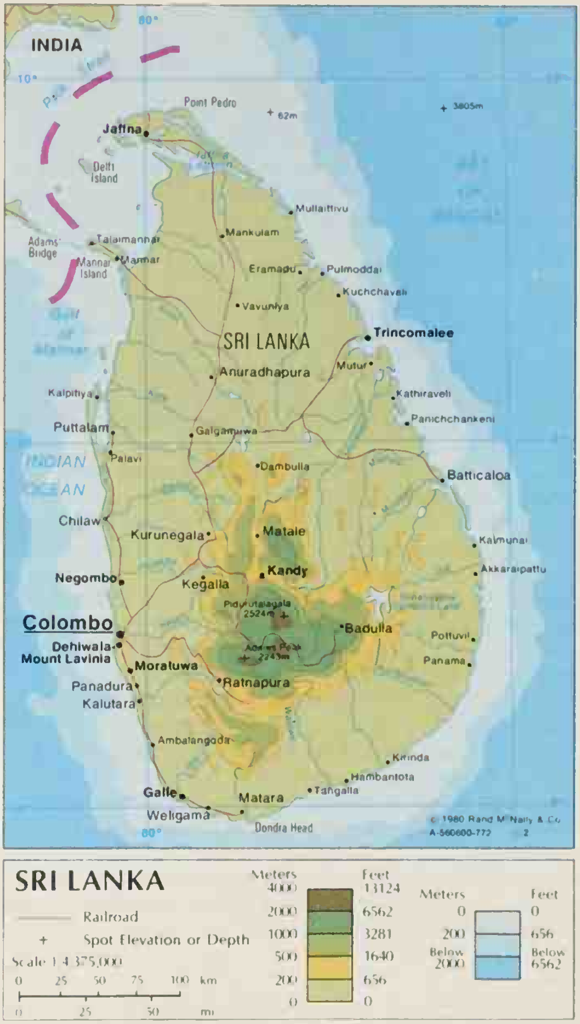
Aside from COLOMBO, the capital, KANDY and Jaffna are the most important cities. A declining death rate, a comparatively high—but slowly decreasing—birthrate, and a large number of young people create a potential for rapid population growth. Government health and welfare services have contributed to a longer life expectancy, but serious health problems, such as malaria, persist.

Universal, free education has resulted in a high literacy rate. University education has been primarily academic rather than technical, an emphasis that has prompted criticism in light of the nation's high unemployment problem.

Economic Activity

The early migrants from India brought with them their practice of irrigated rice farming, which was the basis of the island's economy until the British started plantations. Tea, rubber, and coconuts have since then been by far the most important crops, although the percentage of foreign-exchange earnings they provide declined from 87% in 1972 to 48% in 1985. Concentration on export crops has contributed to a deficit in food production, despite efforts to improve rice yields and enlarge fisheries in recent years.

The government has encouraged the growth of private industry, and manufactured goods (including textiles, clothing, and petroleum products) have surpassed agricultural products as the leading source of foreign exchange. Graphite and gems are also exported. Civil strife has disrupted tourism. Sri Lanka suffers from a chronic balance-of-trade deficit.



Government and History

Since promulgation of a new constitution in 1978, Sri Lanka has had a strong presidential system of government. The cabinet is responsible to the elected parliament. The eight provinces are further subdivided into districts, towns, and villages.

Sri Lanka was known to the ancient Greeks and Romans and has a recorded history dating to the 5th century BC. Buddhism was brought from India during the 3d century BC. During its early history, the island was seldom united under a single ruler, and in the 15th century it paid tribute to China.

The Portuguese arrived in 1505 and found seven indigenous kingdoms. The Dutch defeated the Portuguese in the mid-1600s and controlled most of the island until the British ousted them in 1796. The country became an independent member of the Commonwealth in 1948.

Prime minister Solomon W. R. D. BANDARANAIKE dominated Sri Lankan politics until his assassination in 1959. His wife, Sirimavo BANDARANAIKE, succeeded him, but her radical socialist policies created opposition, and she lost the 1965 elections. Reelected in 1970, she ruled until defeated in the 1977 elections by the conservative United National party, led by J. R. Jayawardene. Jayawardene, who became president in 1978, reduced state control of the economy and focused on rural projects. He was reelected in 1982.

The most serious problem facing the government is the long-standing Sinhalese-Tamil conflict, which turned increasingly violent after 1983 and disrupted the economy. The Tamils felt that they had been discriminated against since independence, and militant Tamils demanded a separate Tamil state in the mostly Tamil Northern Province and the ethnically mixed Eastern Province. On July 29, 1987, Sri Lanka and India signed an accord promising greater autonomy to the Tamils; Indian troops were sent to Sri Lanka to guarantee Tamil compliance. This sparked protests among Sinhalese who feared domination by India and involved Indian troops in combat with Tamil guerrillas who rejected the accord. In 1988, under terms of the accord, the Northern and Eastern provinces were merged, elections for a provincial legislature were held, and Tamil again became an official language. The Eastern Province was to decide later whether to remain in this union. Jayawardene, who did not stand for reelection in December 1988, was succeeded by Ranasinghe Premdasa; their United National party retained its parliamentary majority in the 1989 elections. The last Indian troops withdrew from Sri Lanka on Mar. 24, 1990, but a 13-month-long cease-fire broke down on June 11, and the 7-year-old war between the government and the separatist Liberation Tigers of Tamil Eelam resumed. A new cease-fire was declared in 1991.

Srinagar [sri-nuh'-guhr] Srinagar, the summer capital of the state of Jammu and Kashmir in northern India, is situated in the Vale of Kashmir on the Jhelum River at an elevation of 1,593 m (5,227 ft). The city's population of 531,094 (1981) is more than 85% Muslim. Srinagar is located on the edge of picturesque Dal Lake, noted for its houseboats and floating gardens. The city is a trade and tourist center. Its industries produce carpets, silks, metal goods, and wood carvings.

Landmarks include the Jama Masjid (completed 1402), the largest mosque in Kashmir; Mogul emperor Akbar's 16th-century fort on a hill overlooking the city; the 17th-century Pathar Mosque; and the three Mogul Gardens of Shalimar (1619), Nishat (1620s), and Chashma Shahi (1642). Raja Pravarasen founded the city in the 6th century.

SS The *Schutzstaffel* ("defense echelon"), known as the SS or Black Shirts, was a special arm of the German Nazi party under Adolf Hitler. Founded as a bodyguard for Hitler in 1925, the SS came under the direction of Heinrich HIMMLER in 1929. After Hitler came to power in 1933, Himmler expanded the role of the SS, making it the chief instrument of Nazi terror.

From 1939 to 1945, the SS controlled the GESTAPO and all other elements of the German police through the Reich Central Security Office (RSHA). Also under the RSHA were the *Einsatzgruppen* ("special action squads"), which carried out mass executions of Jews and other racial "undesirables."

During World War II the SS included military units called the *Waffen* (armed) SS, which eventually comprised more than 500,000 men; among them were the Death's Head battalions, which guarded the Nazi CONCENTRATION CAMPS.

Ssu-ma Ch'ien see SIMA QIAN

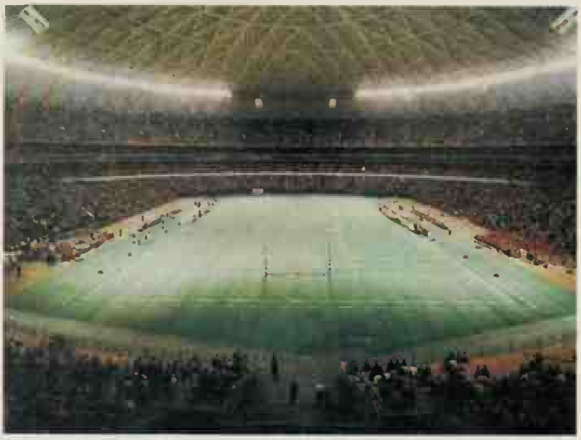
Stabler, Ken Kenneth Michael Stabler, b. Foley, Ala., Dec. 25, 1945, one of the National Football League's (NFL) few left-handed passers, was a star quarterback at the University of Alabama, leading the Crimson Tide to three postseason bowl games. Drafted by the Oakland Raiders in 1968, Stabler did not become a starter until 1973, when he led the American Football Conference (AFC) in passing. In 1976 he led the entire NFL in passing and the Raiders to victory in the Super Bowl. Twice he was named AFC Player of the Year (1974, 1976). In 1980–81, Stabler played for the Houston Oilers, and in 1982–84 for the New Orleans Saints. In his 15-year NFL career he completed 2,270 of 3,793 passes (59.8%) for 27,938 yd and 194 touchdowns.

stadium A stadium is a structure specifically designed for sporting contests and other spectator events. The name comes from the latinized Greek word *stade*, a unit of measurement equivalent to about 184.7 m (606 ft), which was the length of the footrace in the ancient Olympics and the overall length of the ancient Greek stadia. The stadium at OLYMPIA, where the Olympic Games were held, dates from the 4th century BC.

The Greeks also built hippodromes for their chariot races. Wider than the horseshoe-shaped stadia used for athletic contests, these could accommodate several 4-horse chariots. The Roman circus was an adaptation of the hippodrome. The Circus Maximus in Rome was the finest example. The version built in the 1st century BC may have held 250,000 spectators.

The Romans built another type of stadium, called an amphitheater, that appears in those parts of Western Europe where Roman civilization established itself. The best preserved amphitheater is a structure in Arles, France. The most famous is the COLOSSEUM in Rome, built AD *c.*75–80. The size of the arena, the playing area, was not standardized in the amphitheaters and was less important than providing an unobstructed view

The Roman Colosseum is a 4-story, elliptical amphitheater that accommodated about 50,000 spectators around an oval arena. The open-air stadium was the site of gladiatorial events, wild-animal fights, and even mock sea battles.



Seating 66,000 spectators, the domed Houston Astrodome (1965) is one of the world's largest indoor stadiums. The complex is used for many types of sporting events, including baseball, football, basketball, and boxing.

from each of the approximately 50,000 seats.

In the 19th century, when organized sports once again began to attract widespread interest, the stadium reemerged as a significant architectural form. The first modern Olympic Games, held in 1896, gave impetus to modern stadium building. The Athens stadium, which has a capacity of 66,000, was actually constructed using a 2d-century stadium as the base.

The early 20th century saw the construction of more than 100 modern stadia in the United States alone. Almost all were designed for a specific sport. Most of those outside the United States were used primarily for soccer. Most stadia in the United States were built for college football, and many are still in use. The most charming and intimate American stadia from this time, however, were those designed for baseball, with irregular shapes that followed the city streets around them. Forbes Field in Pittsburgh, Pa., built in 1909, and Crosley Field in Cincinnati, Ohio (1912), have been destroyed. Fenway Park (1912) in Boston and Wrigley Field (1922) in Chicago are still in use, however.

The requirements of different sports dictated different kinds of stadia. For American football the U-shaped stadium (Harvard Stadium, Cambridge, Mass., 1912), the ellipse (Yale Bowl, New Haven, Conn., 1914), and facing crescent stands (Northwestern University, Evanston, Ill., 1926) proved best. The original Yankee Stadium (1923) in New York added the innovation of three tiers of seats protected by a roof. Dodger Stadium (1962) in Los Angeles was the first tiered stadium without columns, affording every seat an unobstructed view.

In the 1960s and 1970s a trend developed toward more practical, bowl-shaped multipurpose stadia. These structures featured seats that could be emplaced or removed depending on the sport played. Movable seating was first introduced in Shea Stadium in New York in 1964. Other examples of this kind of stadium are Riverfront Stadium (1970) in Cincinnati and Three Rivers Stadium (1970) in Pittsburgh.

The most startling innovation of recent years, however, is the domed stadium with internal climate control and artificial turf. With its 65,000 seats, the Astrodome (1965) in Houston, Tex., dwarfed other indoor arenas such as New York's first Madison Square Garden (1890), Chicago Stadium (1928), and the Palazzetto dell Sport (1960) in Rome. Other recent domed stadia are the Superdome (1975) in New Orleans, La., the Kingdome (1976) in Seattle, Wash., the Metrodome (1982) in Minneapolis, Minn., the Hoosier Dome (1984) in Indianapolis, Ind., and Olympic Stadium (1987) in Montreal.

The largest stadium in the world is Strahov Stadium in Prague, which was built for gymnastics in 1934 with a capacity of 240,000. Maracaña Stadium in Rio de Janeiro holds 200,000 spectators for soccer.

Staël, Madame de [stahl] A Swiss-French writer famous for her literary criticism, novels, and flamboyant life, Madame de Staël, originally Anne Louise Germaine Necker, b. Apr. 22, 1766, d. July 14, 1817, was one of the most important intellectuals of a changing Europe. The daughter of the politician Jacques Necker, she married the Swedish ambassador Baron de Staël-Holstein in 1786. Banned from Paris by Napoléon in 1803, she established a new salon at Coppet on Lake Geneva.

Madame de Staël wrote voluminously. *De la littérature considérée dans ses rapports avec les institutions sociales* (The Influence of Literature upon Society) was published in 1800 and established her reputation. Her two novels, *Delphine* (1802) and *Corinne* (1807), depict lonely and gifted women caught in a clash of cultures and codes. In

1810 she issued *De l'Allemagne* (On Germany), a major work that investigates German romantic literature and philosophy. Its praise of things German so incensed Napoleon, long her persecutor, that he destroyed the first edition and exiled its author. Her other literary works include a memoir of her father (1804), reflections on Rousseau (1788), and a discussion of the French Revolution (1818).

staff The musical staff, or stave, is a series of parallel horizontal lines that, in conjunction with a CLEF, provides a convenient means of notating pitch. The positioning of notes on or between the lines of the staff, which in case of need can be extended upward and downward through the use of ledger lines, allows quick visual apprehension of the contours of a melody or part. (The visible graph only approximates the musical shape because pitch is indicated by key signature and accidentals as well as by location on the staff.) The five-line staff standard at present is found in some 13th-century manuscripts. Staffs of fewer lines appear earlier—the four-line staff has endured for the notation of plainsong—and staffs of six lines, later.

Stafford, Jean An American novelist and short-story writer, Jean Stafford, b. Corina, Calif., July 1, 1915, d. Mar. 17, 1979, specialized in fiction that explored the effects of isolation on children and adults. The young foreign-born heroine of her first novel, *Boston Adventure* (1944), established Stafford's primary theme, and *The Mountain Lion* (1947), which deals perceptively with a brother and sister's difficult transition from childhood to adolescence, has become a minor classic. Stafford's short stories are collected in *Children Are Bored on Sunday* (1953); *Bad Characters* (1964), which contains "A Winter's Tale"; and the 1970 Pulitzer Prize–winning *Collected Stories* (1969), in which her 1955 O. Henry Prize story, "In the Zoo," appears.

Staffordshire [staf'-urd-shir] Staffordshire is a county in the West Midlands of England, with a population of 1,032,900 (1988 est.). Its area of 2,716 km^2 (1,049 mi^2) is mostly hilly, with limestone moorlands in the north and a central farming region. The area is drained by the River Trent. Stafford (1982 est. pop., 55,100) is the county town. Other important cities are STOKE-ON-TRENT and Burton-on-Trent. Coal mining, dairy farming, brewing, and the manufacture of iron and steel products, shoes, pottery, glass, textiles, and chemicals are mainstays of the economy. Staffordshire was once part of Mercia.

Staffordshire bull terrier The forebears of the Staffordshire bull terrier were the old bulldog and one or more types of British terriers. The old bulldog was used in bullbaiting until this sport was finally outlawed in Britain in 1835. Many of its advocates then turned to dogfighting but found the larger bulldogs too slow, so they crossed the bulldogs with terriers to obtain the faster and lighter bull-and-terrier. In the 1860s the bull-and-terriers were used to develop the dogs now known as bull terriers; the original bull-and-terriers, popular with the workers in Staffordshire, were then called Staffordshire bull terriers.

The English Kennel Club recognized the Staffordshire bull terrier in 1935; the American Kennel Club, in 1974. The dog has a short, deep body; a broad, deep head; a short muzzle; and pronounced, powerful cheek muscles. It carries its ears partly erect. It ranges from 35.5 to 40.5 cm (14 to 16 in) high at the shoulder and from 11 to 17 kg (24 to 38 lb) in weight.

Staffordshire terrier see AMERICAN STAFFORDSHIRE TERRIER

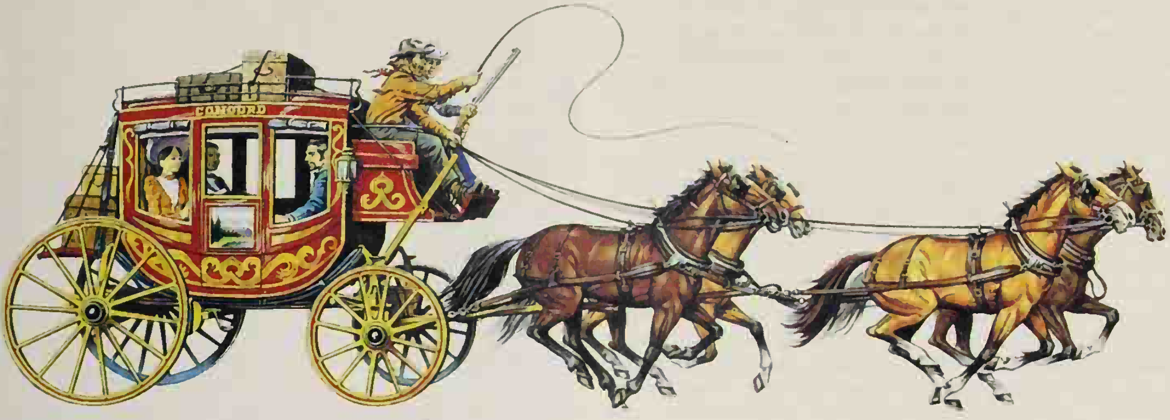
Staffordshire ware see POTTERY AND PORCELAIN

stage lighting Until the Renaissance most dramatic performances occurred in open-air theaters lit by the Sun. When performances moved indoors the stage was illuminated by candles and, later, by oil and gas lamps. The flames of each of these inevitably produced flickering and variations in color and intensity, so the auditorium and the stage remained lit during performances. This changed in 1876, when Richard Wagner darkened the auditorium of the Bayreuth Festspielhaus.

The general theory and practice of lighting was developed during the 16th and 17th centuries by Sebastiano SERLIO, Leone di Somi (1527–92), Nicola Sabbattini (1574–1654), and Angelo Ingegnari (*c.*1550–*c.*1613) in Italy, and by Josef Furttenbach (1591–1667) in Germany. They developed a symmetrical system of stage lighting and experimented with the use of color. Advances since then have focused on increased control and intensity and on adapting lighting to changes in stage architecture and design.

Philadelphia's Chestnut Street Theater in 1816 became the first in the world to light the stage with gas. The limelight, a light with a lime filament that was the prototype of the spotlight, was invented in the same year by Thomas Drummond. Electricity—in the form of the Jablochkoff candle, an electric-arc light—was first used in stage lighting at the Paris Hippodrome in 1878; London's Savoy Theater in 1881 became the first to use INCANDESCENT LAMPS. Electric light allowed more variety and control than ever before and was the perfect complement to naturalistic staging, which developed at the same time.

Much of modern lighting practice is derived from the theories of the Swiss designer Adolphe Appia (1862–1928), who believed that light should be the unifying element of the theater. Since World War I, technology and theory have remained basically unchanged. Most stage lighting today is provided by spotlights, consisting of electric lamps in metal housing with reflectors and lenses to direct and focus the light. Major innovations have been largely in the area of projections.



The stagecoach became the most widely accepted mode of long-distance transportation throughout the American West before the building of the railroads during the late 1800s. Used to convey passengers, mail, or goods, the stagecoach was typically drawn by a team of four or six horses.

stagecoach The stagecoach was a public transport vehicle drawn by a team of four or six horses from one station, or stage, to another on a regular schedule. Long-distance stagecoach lines began operating between some major English cities in the late 17th century, but weather and highwaymen often made a sham of their schedules. American stagecoach lines were begun before the Revolution. Many of the routes they followed are still called post roads because, in addition to passengers and baggage, the coaches carried mail. As in England, inns known as coach houses were established at layover stops between major destinations. Additional horse-changing stations were often established between them. Six-passenger stagecoaches carried drivers and shotgun-holding guards on the outside upper front seat and passengers or two more guards on an outside rear seat. Passengers often had to contend with Indians, robbers, and difficult terrain and weather. The arrival of the railroads ended the stagecoach era, and by the late 19th century, they had disappeared.

stagflation Stagflation is a condition of economic stagnation, or RECESSION, combined with serious INFLATION. Prior to the 1970s inflation was experienced in times of prosperity when demand for goods pushed up prices. In economic slowdowns, unemployment and the consequent drop in consumer spending had a stabilizing effect on prices. That price increases accelerated during the recessions of the 1970s has been attributed at least in part to the economic dislocations caused by large Vietnam War deficits and sharply higher energy costs. Another partial explanation given for stagflation is decreased productivity because of higher costs of production—caused by increased government regulation—and decreased competition in the marketplace—allowing large business firms to reduce output rather than prices. Stagflation makes economic policymaking difficult because the use of fiscal policy and monetary policy, for example, to stimulate the economy out of a recession may increase inflationary pressures, and measures to decrease inflation may lead to slower economic growth.

Stagg, Amos Alonzo Amos Alonzo Stagg, b. West Orange, N.J., Aug. 16, 1862, d. Mar. 17, 1965, was an American college football player and (until 1981) the coach in the history of that sport with the most career victories (314). He played end at Yale University and in 1892 began the first of 41 years as coach at the University of Chicago. There, he compiled a 268-141 won-lost record. He retired at the age of 70 but soon became coach at the College of the Pacific. He retired again after 14 years only to work 3 more years as an assistant at Susquehanna College. Stagg is credited with inventing numerous offensive strategies—around-the-end plays, the flea flicker, hidden-ball plays—and the tackling dummy. He is in the College Football Hall of Fame as both a player and a coach.

Stahl, Georg Ernst [shtahl] Georg Ernst Stahl, b. Oct. 21, 1660, d. May 14, 1734, was a German physician and chemist who developed the ideas of Johannes R. Becher into the PHLOGISTON THEORY. This theory conceived of fire as a material substance. It related such diverse processes as rusting and combustion and served as a unifying principle of chemistry until Antoine Lavoisier developed the oxygen theory in the late 18th century. Stahl taught courses as second professor of medicine at the University of Halle from 1694 until 1716, when he became personal physician to Frederick I of Prussia. A prolific author in both medicine and chemistry, he insisted that truth can be fully demonstrated only by experiment.

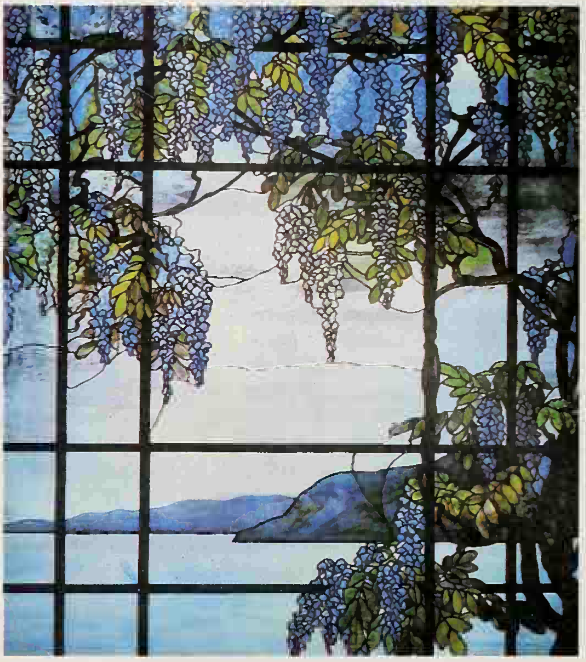
stained glass *Stained glass* is a term used to describe windows composed of colored glass set in designs.

In the West the earliest extant stained glass dates from the 11th century, but the finest stained-glass windows were produced in conjunction with GOTHIC ART AND ARCHITECTURE from about 1130 to 1330. In Islamic countries colored glass, set in wooden or stucco frames in foliate designs, was used beginning in the 12th century.

History. The earliest surviving Western examples are five windows (early 12th century) depicting Old Testament prophets (Augsburg Cathedral, Germany). Extensive use of stained glass, however, first occurred in Abbot Suger's rebuilding (1137–44) of the Royal Abbey of SAINT-DENIS near Paris. That was the direct inspiration for the three great lancet windows (*c.*1150) in the west facade of CHARTRES CATHEDRAL, noted for the famed Chartres blue. Most of the 173 huge windows produced in the next 30 years for Chartres Cathedral remain intact; the church's pictorial program was followed in the windows of Gothic churches throughout France and England. The SAINTE-CHAPELLE in Paris, built 1243–48, contains 15 enormous windows with 1,134 narrative scenes that form walls of glass and mark the apogee of Gothic stained glass.

Gothic stained glass owes much of its beauty to the deliberately flat, two-dimensional design perfectly suited to the medium. By the late 14th century, perspective had been introduced in stained-glass design in imitation of painting, which led to a debasement of the art that reached its lowest point in the 18th century. The 19th-century GOTHIC REVIVAL in architecture led to a rebirth of stained glass for both religious and secular buildings. William Morris and Sir Edward Burne-Jones spurred the revival in England, which then spread to the United States, where its most successful practitioners were John LA FARGE and Louis Comfort TIFFANY. The abstract secular designs of the German Ludwig Schaffrath and the windows by Henri Matisse for the Dominican Chapel of the Rosary (1951) in Vence, France, are the most notable works of modern times. In the United States the Air Force Academy Chapel, Colorado Springs, Colo. (1959), is almost entirely of stained glass suspended in aluminum frames, recalling Sainte-Chapelle's walls of glass.

Louis Comfort Tiffany's Oyster Bay window (c.1905), a landscape viewed through a wisteria trellis, exhibits the curving natural forms typical of Tiffany's Art Nouveau creations. (Morse Gallery of Art, Winter Park, Fla.)



Technique. Stained-glass technique has changed little since its development in the 11th century. Pieces of glass of various colors are placed together on a full-size model or drawing of the window. They are joined with lead strips that are soldered in place. The assembled panels are then suspended in the window frame or the stone tracery on iron bars called armatures. The colors were achieved by mixing metal oxides with the molten glass during smelting; the Chartres blue was obtained from cobalt mined in Bohemia (the mines were exhausted by the 14th century, and this azure blue could not be reproduced until the 20th century); red was obtained from oxidized copper; green from bioxide of copper; purple from manganese mixed with cobalt; and yellow from manganese and ferrous oxide. Facial features, decorations, and lettering were painted in grisaille, a gray-brown enamel baked on the glass. Once believed to be impervious to the effects of time, stalned glass has proved fatally susceptible to air pollution.

stainless steel Stainless steels are iron-based alloys that have a very high resistance to rusting and corrosion because of their chromium content, which is greater than that found in other types of steel. Nickel, molybdenum, and other elements are also used, in addition to chromium, to produce stainless steels with a great range of properties. The most widely manufactured stainless steel is the alloy known as "18-8," containing 18% chromium, 8% nickel, and 0.15% carbon. This alloy can be formed into precisely detailed, complicated shapes and is commonly used for making flatware, cooking utensils, and plumbing fixtures and for a variety of processing and manufacturing machinery and equipment.

Stainless steels are melted almost exclusively in the electric-arc furnace and are semifinished in slab, rod, or tube form. Finished steels are available in many different forms—plate, sheet, strip, bar, wire, or tubing. Many stainless steel products are produced by casting.

Because of their extraordinary rust and corrosion resistance, stainless steels do not require protective coatings, and the polish produced by a final finishing is extremely durable.

See also: IRON AND STEEL INDUSTRY.

This spectacular formation of stalactites (top) *and stalagmites* (bottom), *in the Cave of Clamouse in southern France, was formed from minerals deposited by dripping water.*

stalactite and stalagmite Stalactites and stalagmites are formations found on the ceiling and floor, respectively, of a cave. Groundwater seeping into a cave chamber contains carbon dioxide (CO_2) absorbed from the atmosphere or the soil. The carbon dioxide may unite with limestone ($CaCO_3$) to form calcium bicarbonate ($CaHCO_3$), which also may be dissolved and carried in the water percolating through the cave. When the water carrying calcium bicarbonate evaporates, it releases carbon dioxide, and the remaining molecules are normally deposited as crystals of calcium carbonate (calcite or aragonite).

If the crystals remain in contact with the ceiling they build up as a stalactite, a small, circular, hollow tube. The water continues to flow down the center until the stalactite may be 1 m (3 ft) in length, or longer, although stalactites are rarely more than 5 mm (0.2 in) in diameter. The presence of some minerals such as copper or iron results in a colored stalactite.

Stalagmites are produced when water drops directly to the cave floor. The impact of the water striking the floor causes it to break into droplets or into a film, releasing excess carbon dioxide, and calcite crystals begin to grow upward. If a stalactite and a stalagmite meet, they form a column. Stalagmites are usually larger in diameter than stalactites, have rounded tops, and possess no central canal. Some stalagmites are 10 m (33 ft) tall, and they can range up to 10 m in diameter.

The rate of growth of stalactites and stalagmites varies depending on the rate at which water percolates from the surface. An average rate of growth is approximately 2 mm (0.08 in) per year, but too many variables are involved for their age to be determined from this.

Stalin, Joseph [stah'-lin] Joseph Stalin, b. Joseph Vissarionovich Djugashvili, Dec. 21 (N.S.), 1879, d. Mar. 5, 1953, became the preeminent Soviet leader after the death of Vladimir I. LENIN in 1924. From 1929 until his own death, Stalin held absolute authority. Outwardly modest and unassuming and intellectually unimpressive, he applied a shrewd intelligence to political organization and manipulation. Stalin brought his country to world-power status but imposed on it one of the most ruthless regimes in history.

Early Life and Career. Stalin was born in the Georgian hill town of Gori. His father, an unsuccessful shoemaker, was an alcoholic who died in a brawl when the boy was 11 years old. Stalin's mother, Ekaterina, was a washerwoman, hopeful that her sole surviving child would be a priest. At the age of 14, Stalin entered the Tiflis Theological Seminary, but in 1899 he left the seminary without graduating and became a full-time revolutionary organizer. A member of the Georgian branch of the Social Democratic party by 1901, Stalin roamed the Caucasus, agitating among workers, helping with strikes, and spreading socialist literature.

When the Social Democrats split (1903) into two groups, the BOLSHEVIKS AND MENSHEVIKS, Stalin supported the more radical Bolsheviks and their leader, Lenin. Between 1902 and 1913, Stalin was arrested many times but repeatedly escaped. During these years he also staged robberies to obtain funds for the Bolsheviks.

The Road to Absolute Power. In 1912, Stalin was co-opted by Lenin to the Bolshevik Central Commitee and then rapidly gained influence and served as the first edi-

Joseph Stalin, dictator of the USSR after the death of Lenin, forced Russia's rapid change from an agrarian nation to a major industrial power and led his country to victory in World War II. Stalin's achievements, however, must be measured against his brutal methods, constituting a reign of terror.

tor of *Pravda*, the party newspaper. He also began to use the name *Stalin*, meaning "man of steel." During the RUSSIAN REVOLUTIONS OF 1917, Stalin played an important role after the first unsuccessful Bolshevik attempt to seize power (the "July days") when Leon TROTSKY was arrested and Lenin was forced into hiding. Following the successful November Revolution, Stalin was appointed to several seemingly mundane administrative posts, but in 1922, without fanfare, he became general secretary of the party's Central Committee.

After Lenin's death in 1924, Stalin used his control of the party apparatus to crush his opponents. For his deemphasis on world revolution under the slogan "socialism in one country" and his moderate economic policies, the general secretary was attacked by Trotsky, who was belatedly joined by Lev KAMENEV and Grigory ZINOVIEV. By 1928, Stalin had driven this leftist opposition from its party posts. Then he smashed the party's right, which was led by Nikolai BUKHARIN, for opposing measures that he himself had recently attacked. By the end of 1929, Stalin was the undisputed master of the USSR.

Collectivization and Industrialization. Stalin's program of farm collectivization began late in 1928 when he suddenly ordered the expropriation of the lands of the middle-class farmers, or KULAKS. Brutally suppressing peasant resistance, Stalin refused to slacken the pace despite a famine in 1932 and mounting opposition within his own party. Disaffection with Stalin was manifest at the 17th Party Congress in January–February 1934, when Leningrad party leader Sergei Kirov, a favorite of moderate delegates, received an ovation equal to Stalin's. Peasant resistance was quashed, however, and collectivization proved a success in terms of facilitating rapid industrial growth.

The Great Purge. Stalin subsequently turned on all those who appeared to have disagreed with him. In December 1934, Kirov was assassinated at the behest of Stalin, who used the murder as the pretext for eliminating the Bolshevik "Old Guard." From 1936 to 1938 he staged the Moscow show trials, at which the defendants confessed to implausibly monstrous crimes. By 1937, Stalin's blood purge extended throughout the country. Millions died, including those who perished in concentration camps. At the same time, Stalin began promoting a cult of adulation that proclaimed him a genius in every field of human endeavor.

World War II Leadership. After abortive attempts to reach an accord with the Western democracies, Stalin concluded (1939) a nonaggression treaty (see NAZI-SOVIET PACT) with Hitler. When Germany invaded Poland at the start of World War II, Stalin occupied eastern Poland and attacked Finland (see RUSSO-FINNISH WAR). The nonaggression pact with Germany, however, proved short-lived; German troops invaded the Soviet Union in June 1941.

Taking personal control of the armed forces, Stalin expended troops as easily as he had executed kulaks. Commanding his army directly on a day-to-day basis, he impressed foreign observers tremendously with his grasp of detail. He proved a skillful negotiator at the major Allied conferences (see YALTA CONFERENCE; POTSDAM CONFERENCE).

Last Years. In 1945, Stalin was at the height of his power and prestige, but the following years saw a new wave of repression. Returned prisoners of war were incarcerated in concentration camps and new duties on peasants reduced many to the status of serfs. The imposition of Communist regimes on Eastern European initiated the COLD WAR. In early 1953, Stalin announced that he had uncovered a plot among the Kremlin's corps of doctors and many feared another great purge, but Stalin died soon after.

Stalin's reputation declined in the USSR after Nikita KHRUSHCHEV revealed many of his crimes in 1956, but Khrushchev's immediate successors downplayed anti-Stalinist rhetoric. The full extent of Stalin's terror was only made public in the USSR after Mikhail Gorbachev introduced his policy of GLASNOST in the late 1980s.

Stalingrad, Battle of see WORLD WAR II

Stamford [stam'-furd] Stamford, a city in southwestern Connecticut, about 50 km (30 mi) northeast of New York City, has a population of 108,056 (1990). Settled in 1641, Stamford became known in the 19th century for its inventions and industries. There Simon Ingersoll invented the friction clutch and the spring scale, and Linus Yale, Jr., invented the cylinder lock in 1848. After World War II the city underwent rapid growth and became a center for major corporate headquarters. The city's industries produce machinery, hardware, computers, and plastics. Suburban and semirural areas occupy the hills and ridges north of the city. Stamford is a residential community for many commuters to New York City. Of interest are the Stamford Museum and Nature Center, with its planetarium, and the fish-shaped First Presbyterian Church (1958).

Stamitz (family) [shtah'-mits] The Bohemian composer and violinist **Johann Wenzel Anton Stamitz**, b. June 19, 1717, d. Mar. 27, 1757, was an important preclassical symphonist and founder of the Mannheim school. His virtuoso performances on the violin and other stringed instruments led to his engagement by the Mannheim court in 1741. By 1745 he was concertmaster and director of the orchestra, which became famous for its precision, control of dynamics, and brilliant ensemble playing. He remained in Mannheim, except for a triumphant year (1754–55) in Paris, where his symphonies were performed and published. About 70 of Stamitz's symphonies, numerous concerti, and chamber works survive. His symphonies are notable for their incipient sonata form, symmetrical phrase patterns, and distinctive treatment of wind instruments—all features adopted into the classical style. Johann's son **Carl Philipp Stamitz**, b. May 7, 1745, d. Nov. 9, 1801, played in the Mannheim orchestra from 1762 to 1770, later traveling throughout Europe as a violin virtuoso. He composed about 80 symphonies and other instrumental music.

stammering see STUTTERING

Stamp Act The Stamp Act (Mar. 22, 1765), sponsored by George GRENVILLE, was the first direct tax imposed by Britain on its American colonies. To help cover the cost of maintaining troops in the colonies, Parliament levied a tax on legal and commercial documents as well as printed material, such as newspapers and pamphlets, all of which had to carry a special stamp. The act took effect in November 1765. Americans, who did not elect members of Parliament, opposed the act not only because of their inability to pay the tax, but also because it violated the newly enunciated principle of "No taxation without representation."

Resistance to the statute took the form of petitions to the king and Parliament, a boycott of British goods, the refusal of lawyers or printers to use stamps or stamped paper, and violence sparked by the SONS OF LIBERTY. The Massachusetts legislature spearheaded the formation of the first general intercolonial conference, the Stamp Act Congress, which met (October 1765) in New York City and issued a declaration of American rights and grievances. Parliament rescinded the statute on Mar. 18, 1766, but it coupled repeal with passage of the Declaratory Act, which asserted Britain's supremacy over America "in all cases whatsoever." The constitutional principles and protest tactics established during the Stamp Act crisis laid the groundwork for the American Revolution.

stamp collecting see PHILATELY

standard deviation see STATISTICS

Standardbred The Standardbred is a breed of horse used primarily in harness racing, both trotting and pacing. The breed is part of the social history of Canada and the United States, where it was developed from Thoroughbreds, Norfolks, Morgans, and Arabians in the 19th century.

The Standardbred horse is renowned for its ability to trot at high speeds without breaking into a gallop. It was used to pull buggies, phaetons, and other vehicles in the years before the automobile.

The Standardbred resembles the Thoroughbred but is smaller, with heavier bones, a longer body, shorter legs, and greater endurance. The weight is about 400 to 520 kg (900 to 1,150 lb), and the height at the withers (shoulders) is about 15 hands (1.5 m/60 in). The most common color is bay.

The name *Standardbred* originated when horses were required to meet certain standards of speed in order to be registered in the official studbook, which was begun in 1871.

Stable and long-lived, the Standardbred is one of the most durable horses developed by American breeders. It has been exported worldwide for racing and utility purposes.

standing wave see WAVES AND WAVE MOTION

Standish, Myles Myles Standish, b. *c.*1584, d. Oct. 3, 1656, an English-born professional soldier, was hired by the PILGRIMS as military advisor for their PLYMOUTH COLONY in America; eventually he became a full member as well as a valued leader of the community. Arriving on the *Mayflower* with the first settlers, he initially concentrated on colonial defense and Indian relations. Later, Standish represented (1625-26) Plymouth in England; he also served for many years as one of the governor's assistants and as the colony's treasurer (1644-49). Standish was one of the founders (1632) of the town of Duxbury, Mass.

Stanfield, Robert Lorne The Canadian political leader, Robert Lorne Stanfield, b. Truro, Nova Scotia, Apr. 11, 1914, served as premier of Nova Scotia from 1956 to 1967, when he resigned to become a member of Canada's House of Commons and leader of the opposition Progressive Conservative party. In 1974, Stanfield's party was defeated by the Liberal party under Pierre Elliott Trudeau; Stanfield resigned as party leader.

Stanford, Leland The American railroad magnate and politician Leland Stanford, b. Watervliet, N.Y., Mar. 9, 1824, d. June 21, 1893, served as Republican governor (1861-63) of California and U.S. senator (1885-93) from California. After being admitted to the bar in 1848, Stanford practiced law in Wisconsin until 1852, when he joined his five brothers in California and became a merchant. As governor he helped keep that state in the Union in the early part of the Civil War. In 1861, with Collis P. Huntington, Stanford started the Central Pacific Railroad Company, and in 1870 he founded the Southern Pacific Railroad Company. In 1885, Stanford founded Stanford University with a grant of $20 million.

Stanford-Binet test [stan'-furd-bee-nay'] The Stanford-Binet test is a measure of intelligence administered individually to children. Originated by the French psychologist Alfred Binet in 1905, it was modified at Stanford University by Lewis Terman in 1916, revised in 1937 and again— by Terman and Lewis Merrill—in 1960. Performance on the original Binet test was expressed in terms of an age scale, a basal age being established at the age level at which the individual under examination passed all tests; additional months of credit were applied for tests passed above the basal-age level. The result was a designation of "mental age."

In the ensuing work at Stanford it was considered necessary to have an index relating the mental age level to the typical performance of the individual's age group. For this purpose, the intelligence quotient, or IQ, was adopted in the modified Stanford-Binet test. A ratio of the mental-age factor (MA) to the chronological-age factor (CA) provides an index of relative performance (see psychological measurement).

The Stanford-Binet test is based on a standardization of average performances by age label, having a value of approximately 100 with variations consistently in the range of about 16 above or below 100. Results of the Stanford-Binet test have been shown to be fairly consistent with individual performance over a period of years; this stability has resulted in a widespread application of the Stanford-Binet test as a measure of intelligence. The test does not account, however, as more recent ones do, for developmental and environmental factors in intelligence levels. For criticism of intelligence testing in general, see intelligence.

Stanford Linear Accelerator Center see accelerator, particle

Stanford University Established in 1885, Stanford University is a private coeducational institution in Stanford, Calif. Officially named Leland Stanford Junior University, for the son of Leland Stanford, it offers undergraduate and graduate degrees in its schools of humanities and sciences, earth sciences, engineering, law, medicine, education, and business. The university has a medical center, a marine station at Pacific Grove, a food research institute, and the Hoover Institution on War, Revolution and Peace. The university has 11 overseas study centers.

Stanislaus, Saint [stan'-is-laws] Saint Stanislaus (Stanisław), b. July 26, 1030, d. Apr. 11, 1079, is the patron saint of Poland. Bishop of Kraków from 1072, he was murdered by King Bolesław II after he excommunicated the king for his scandalous conduct. Stanislaus was the first Pole to be canonized (1253). Feast day: Apr. 11 (formerly May 7; May 8 at Kraków).

Stanislavsky, Konstantin [stuhn-is-lahf'-skee] In establishing his "method" for teaching actors to realize a greater degree of verisimilitude on the stage, the Russian actor and producer Konstantin Stanislavsky (whose original name was Alekseyev), b. Jan. 17 (N.S.), 1863, d. Aug. 7, 1938, launched the age of the great director in modern theater. In his early career he was associated with the semiprofessional Society for Art and Literature, both as an actor of classic roles and as an innovative producer.

In 1897, together with Vladimir Nemirovich-Danchenko, Stanislavsky founded the Moscow Art Theater, dedicated to bringing art to a larger public and to the more realistic (or truthful) presentation of new plays. The new group achieved its first notable success with Anton Chekhov's *The Seagull* (1898). The absence of dramatic gesture, rhetorical declamation, and purposeful plot in Chekhov's plays—including also *Uncle Vanya* (1899), *The Three Sisters* (1901), and *The Cherry Orchard* (1904), all produced by the Moscow Art Theater—demanded new acting techniques, which Stanislavsky believed must be discovered by the actor in the "indirect action" and "subtext" of the dialogue. By putting himself or herself in the character's place, the actor was to experience the character's internal emotions (see method acting). Stanislavsky often used a tic or idiosyncratic gesture to convey the essence of a character.

Other important plays directed by Stanislavsky included Ostrovsky's *Snow Maiden* (1900), Ibsen's *An Enemy of the People* (1900–01), Gorky's *The Lower Depths* (1902), and, following the Bolshevik revolution, later Soviet plays as well.

Stanislavsky sponsored three successive studios at the Art Theater and headed the Opera Studio. His theories are contained in *My Life in Art* (1924), written in English while touring the United States, *An Actor Prepares* (1926; Eng. trans., 1948), *Building a Character* (Eng. trans., 1949), and *Creating a Role* (Eng. trans., 1961).

See also: Actors Studio; Group Theatre, The.

Stanisław I, King of Poland [stan'-is-luhv] Stanisław I Leszczyński, b. Oct. 20, 1677, d. Feb. 23, 1766, was twice king of Poland (1704–09, 1733–34). He was initially elected and crowned king with the support of Charles XII of Sweden, who was fighting Peter I of Russia and his ally Augustus II of Poland in the Great Northern War. Stanisław lost his throne when Peter defeated (1709) Charles at Poltava. In the War of the Polish Succession (1733–35) he was once more elected king, with the support of Polish nobles and of his son-in-law, Louis XV of France. A year later, however, he was deposed by Russian forces, and the Austro-Russian candidate Augustus III was installed on the throne. Stanisław, who fled the country, was given Lorraine and Bar for life by the Treaty of Vienna (1738). He became a writer and a patron of the arts.

Stanisław II, King of Poland Stanisław II, b. Jan. 17, 1732, d. Feb. 12, 1798, last king of Poland

(1764–95), an enlightened monarch and great patron of the arts, struggled vainly against the Partitions of Poland (see POLAND, PARTITIONS OF) by Russia, Austria, and Prussia. He wanted to modernize Poland and hoped for Russian support, believing that Russian interest required a strong Polish ally against Austria and Prussia. Russian empress CATHERINE II, however, had put Stanisław, her former lover, on the Polish throne to have an obedient satellite, and she obstructed reforms that would strengthen Poland. After the first partition (1772), Stanisław helped draft the Polish constitution of 1791, which established a constitutional monarchy and was the first written constitution in Europe. After the second partition (1793), he continued to work to preserve a Polish state. He abdicated just prior to the third partition (1795).

Stanley, Sir Henry Morton Sir Henry Morton Stanley, b. John Rowlands in Wales, Jan. 28, 1841, d. May 10, 1904, was a British-American journalist and explorer who achieved fame in 1871, when he found the Scottish missionary and explorer David LIVINGSTONE. Stanley grew up in a workhouse and at age 16 he sailed for New Orleans, where he was adopted by a cotton broker named Stanley.

In 1867, Stanley obtained his first regular journalistic position as a reporter for the *St. Louis Weekly Missouri Democrat*. In 1868 he persuaded the *New York Herald* to send him to find Livingstone, who was "lost" in the heart of Africa. In 1871, Stanley located Livingstone in Ujiji, in what is now Tanzania (and greeted him with the famous words, "Dr. Livingstone, I presume?"). Three years later he returned to Africa and between 1874 and 1877 circumnavigated Lakes Tanganyika and Victoria, traced the unexplored Congo River to its mouth, and began an era when explorers sought imperial goals. In 1880, on a second trip to the Congo, Stanley secured the south bank of the river for Leopold II, king of the Belgians. From 1887 to 1889, Stanley sought to "save" Emin Pasha, governor of Egypt's Equatorial Province, supposedly marooned in the Upper Sudan. With great loss of life, Stanley led his large expedition to the Indian Ocean and in the process established the basis of British East Africa. In retirement Stanley sat (1895–1900) in the British Parliament. He was knighted in 1899.

Stanley Cup see ICE HOCKEY

Stanleyville see KISANGANI

Stanovoi Range [stuh-nuh-voy'] The mineral-rich Stanovoi Range of the USSR lies in eastern Siberia north of Manchuria. The east-west-trending range, which is 725 km (450 mi) long, reaches its maximum elevation at Golets Skalistiy (2,482 m/8,143 ft), located in the easternmost part. The mountains form part of the watershed be tween the Pacific and Arctic oceans.

Edwin M. Stanton, U.S. Secretary of war during the Civil War and Reconstruction, was at the center of the struggle between President Andrew Johnson and the Radical Republicans. Johnson's suspension of Stanton from his post—in violation of the Tenure of Office Act—led to the president's impeachment.

Stanton, Edwin M. Edwin McMasters Stanton, b. Steubenville, Ohio, Dec. 19, 1814, d. Dec. 24, 1869, served as U.S. attorney general (1860–61) and secretary of war (1862–68) in the U.S. Civil War and Reconstruction era. Stanton was a moderately active Democratic party worker and a successful lawyer before President James Buchanan appointed him attorney general in December 1860. Although Stanton had been allied with the pro-Southern wing of the Democratic party before the secession crisis (November–December 1860), he worked secretly with Republicans and cooperated with firm opponents of secession in the cabinet, helping to force the resignations of members of the cabinet's Southern bloc—and to prevent Buchanan's capitulation in the crisis. Resigning when Republican President Abraham Lincoln took office in March 1861, Stanton remained close to both Democratic and Republican leaders.

In January 1862, Lincoln named Stanton secretary of war. In that position, he earned a reputation for energy and administrative ability as well as for abrasiveness. He became Lincoln's chief cabinet advisor and a major cabinet link to Republican congressional leaders, who urged more vigorous prosecution of the war and stronger measures against slavery.

Stanton retained his post under President Andrew JOHNSON. As the differences between Johnson and most Republican leaders grew over Reconstruction policy, Stanton attempted to bridge the gap. The struggle between Johnson and Republican leaders in Congress intensified, however, and Stanton's position became more anomalous. After March 1867, when Congress put the army in charge of Reconstruction, Stanton used his post to prevent Johnson from subverting congressional policy. Johnson suspended him from office in August 1867, but under the terms of a new law—the TENURE OF OFFICE ACT, which was designed to limit the presidential power of removal—Stanton was restored (January 1868) when the Senate refused to concur in the president's action. Johnson's attempt to fire Stanton on Feb. 21, 1868, in defiance of the law, led to the president's impeachment and trial. Stanton relinquished control of his office in May 1868, after the Senate acquitted Johnson.

Stanton, Elizabeth Cady The American reformer Elizabeth Cady Stanton, b. Johnstown, N.Y., Nov. 12, 1815, d. Oct. 26, 1902, was a founder of the organized women's-rights movement in the United States. She was also active in the antislavery and temperance movements. Marrying abolitionist Henry B. Stanton in 1840, she insisted on the omission of "obey" from the marriage vows. She and Lucretia MOTT organized the SENECA FALLS CONVENTION (July 19–20, 1848), the first women's-rights assembly in America. There, Stanton drafted a Declaration of Sentiments that paralleled the wording of the Declaration of Independence and insisted, over some objections, on adoption of a women's-suffrage resolution (see SUFFRAGE, WOMEN'S). She was also an advocate of more liberal divorce laws, less restrictive clothing for women, coeducation, and the right of married women to control their property. From 1851, Stanton and Susan B. ANTHONY worked together in the women's-rights movement. Stanton coedited (1868–70) the feminist journal *Revolution* and was the first president of both the National Woman Suffrage Association (1869–90) and the National American Woman Suffrage Association (1890–92).

Elizabeth Cady Stanton organized the first U.S. women's rights convention in 1848 and was a leader in the struggle to win voting and property rights for women. Together with Susan B. Anthony she edited a newspaper, the Revolution. *She was also coauthor of a six-volume work,* History of Woman Suffrage.

Stanwyck, Barbara The American actress Barbara Stanwyck, b. Ruby Stevens in Brooklyn, N.Y., July 16, 1907, d. Jan. 20, 1990, appeared in more than 80 films and was best known for parts that called for tough, aggressive characterizations. Her best portrayals, for which she was an Academy Award nominee, were in *Stella Dallas* (1937), *Ball of Fire* (1941), *Double Indemnity* (1944), and *Sorry, Wrong Number* (1948). Stanwyck also starred in two television series, "The Barbara Stanwyck Theatre" (1960–61) and "The Big Valley" (1965–69). She received three Emmy Awards (1961, 1966, 1983), an honorary Academy Award (1982), and the American Film Institute life achievement award (1987).

Staphylococcus [staf-i-luh-kahk'-uhs] *Staphylococcus* is a genus of spherical bacteria, some species of which are normal inhabitants of the skin and others of which cause disease. The most common pathogen, *S. aureus*, is frequently responsible for boils, carbuncles, abscesses, osteomyelitis, and, sometimes, meningitis and pneumonia, and is the most common cause of bacterial food poisoning and hospital infections.

star A star is a large ball of hot gas, thousands to millions of kilometers in diameter, emitting large amounts of radiant energy from nuclear reactions in its interior. Stars differ fundamentally from planets in that they are self-luminous, whereas planets shine by reflected sunlight. Except for the SUN, which is the nearest star, stars appear only as points of light, even in the largest telescopes, because of their distance.

The brightest stars have long been given names. Most of the familiar names originated with the ancient Greeks or with later Arab astronomers; an entirely different system was used by the Chinese, starting hundreds of years earlier, about 1000 BC. Polaris, the North Star, has a Greek name; Betelgeuse, a bright red star, has an Arabic name. Modern astronomers designate the bright stars according to the CONSTELLATIONS they are in. For example, the star Polaris in the constellation Ursa Minor is called gamma (γ) Ursa Minoris. VARIABLE STARS (stars that periodically change in brightness) have lettered names, such as RR Lyrae in the constellation Lyrae. Fainter stars are known by a catalog number: thus, HD 12938 is the 12,938th star in the *Henry Draper Catalogue.*

Stars exist alone or in systems of two or more stars. Larger groupings are called clusters, and stars and star clusters are collected in very large groupings called galaxies. Our GALAXY, the Milky Way, contains more than 100 billion stars. Tens of millions of galaxies are known to exist, so the total number of stars in the universe exceeds a billion billion.

Characteristics of Stars

Stars are seen in the same relative positions, year after year. They provided early astronomers with a reference system for measuring the motions of planets ("wandering stars"), the Moon, and the Sun. The apparent westward rotation of the celestial sphere is caused by the daily eastward rotation of the Earth, and the Sun's apparent motion among the stars is the result of the Earth's annual orbit around the Sun.

Positions, Motions, and Distances. As the construction of larger telescopes improved the accuracy of determining stellar positions, it was found that stars are not precisely "fixed." They move at various speeds, measured as changes of direction in fractions of a second of arc per year, where one second of arc is the angular size of a pinhead 183 m (200 yd) away. Most of the faint stars are truly fixed as viewed from Earth and are used as a reference frame for the minute motions of nearby stars, known as PROPER MOTION.

PARALLAX is another apparent motion of nearby stars. It is caused by the Earth's orbit around the Sun: the star seems to shift, first one way, then the other, as the Earth moves from 150 million km (93 million mi) on one side of the Sun to 150 million km on the other side. Stellar parallax can be used to determine astronomical DISTANCE. If the shift is 1 second of arc each way, the star is about 32 million million km (20 million million mi) from an observer. This distance is called the parsec and is equal to 3.26 light-years.

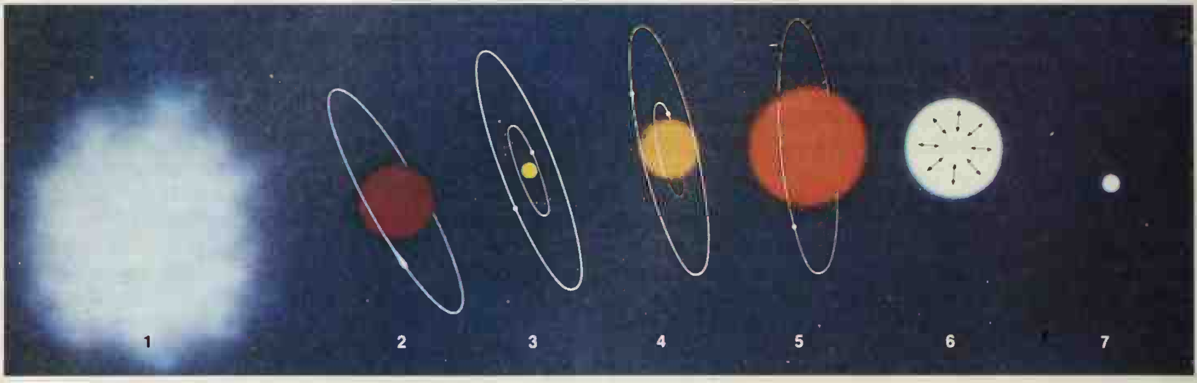
Brightness and Luminosity. Star brightness was first estimated by eye, and the brightest stars in the sky were described as "stars of the first magnitude." Later, the magnitude scale was defined more accurately: 6th magnitude stars are just 1/100 as bright as 1st magnitude stars; 11th magnitude stars are 1/100 as bright as 6th magnitude, and so on. The magnitude scale is logarithmic; that is, each magnitude corresponds to a factor of 1/2.54, because $(1/2.54)^5 = 1/100$ (see MAGNITUDE).

Photographs are also used to measure star brightness. With the photographic emulsions available in the early 1900s, a blue star that appeared to the eye to have the same brightness as a red star photographed much brighter. This discrepancy occurred because emulsions at that time were much more sensitive to blue light than to red. Because of this variation, two magnitude scales came into use: visual magnitude (m_v) and photographic magnitude (m_p). The difference for any one star, m_p-m_v, measures the color of that star—positive for red stars, negative for blue (see COLOR INDEX). By using filters and special emulsions, astronomers soon had several other magnitude scales, including ultraviolet and infrared. When photoelectric detectors were introduced, the brightnesses of stars were measured with a photoelectric photometer at the focus of a telescope. Standard colors (wavelengths) of light were adopted, and the symbols m_v and m_p were changed to V and B, with U for the ultraviolet scale, and several other letters for infrared scales.

By comparing a star with a standard at the same height above the horizon, astronomers using photoelectric photometers can measure U, B, and V magnitudes with an accuracy of 0.01 magnitude (see PHOTOMETRY, ASTRONOMICAL).

Such photometry has provided a great deal of information regarding the temperatures and energy output of stars, but it does not give the total energy output. Each measurement (U, B, V) gives only a fraction of the star's light reaching the Earth; even if the measurements are combined, they give only the part that is not absorbed as it passes through the Earth's atmosphere. The atmosphere absorbs all light of short wavelengths below ultra-

The Pleiades, the most famous of the open clusters, is visible in the constellation of Taurus. Although a telescope reveals several hundred stars in the cluster, only the six brightest are normally visible to the unaided eye. The Pleiades is also the best-known example of a reflection nebula, in which a cloud of dust surrounding the hot stars reflects each star's light toward Earth.



Astronomers believe that stars are continuously forming, evolving, and dying out. A large rotating cloud (1) *of gas and dust is thought to contract* (2) *as a result of mutual gravitational attractive forces to form a nuclear-reacting star* (3) *and perhaps a number of cold orbiting planets. Eventually, a star like the Sun will undergo a new series of internal reactions that will cause it to expand* (4) *into a red giant* (5). *When most of the nuclear fuel is consumed, the star will pulsate* (6) *and finally contract to a cooling white dwarf* (7).

violet and many of the long wavelengths above red. A theoretical correction can be made, based on the star's temperature, to give a "bolometric" magnitude, m_b, adding the energy absorbed by the atmosphere. True bolometric magnitudes, however, are measured only from rockets and spacecraft outside the Earth's atmosphere.

From parallax-distance measurements it is possible to calculate the absolute bolometric magnitude, or luminosity, of a star, which is a measure of its brightness relative to the Sun if it were at the Sun's distance from an observer on Earth. During the 1920s it was found that some stars (giants) are 100,000 times as luminous as the Sun; others (white dwarfs) are 1,000 times less luminous.

Composition. The composition of the stars did not become known until the invention of the SPECTROSCOPE in the 19th century. Through the refraction of light by a PRISM or through its diffraction by a DIFFRACTION GRATING, the light from a source is spread out into its different visual wavelengths, from red to blue; this is known as its SPECTRUM. The spectra of the Sun and stars exhibited bright and dark lines, which were shown to be caused by elements emitting or absorbing light at specific wavelengths. Because each element emits or absorbs light only at specific wavelengths, the chemical composition of stars can be determined. In this way the spectroscope demonstrated that the gases in the Sun and stars are those of common elements such as hydrogen, helium, iron, and calcium at temperatures of several thousand degrees. It was found that the average star's atmosphere consists mostly of hydrogen (87%) and helium (10%), with all other elements making up about 3%. Helium was actually first discovered in the Sun's spectrum.

Although the ultraviolet, visual, and infrared parts of a star's spectrum can be measured by standard photographic or photoelectric methods, in this way, other techniques must be used, above the atmosphere, to measure the shorter wavelength spectra of X-ray stars and gamma-ray stars. Instead of gratings and prisms, various combinations of filters and detectors are used to measure portions of the X-ray and gamma-ray spectra. At the other extreme (long wavelengths), radio spectra of stars and other radio sources are measured by "tuning" a radio telescope to different frequencies (see RADIO ASTRONOMY).

Spectral Type and Surface Temperature. During the early decades of the 20th century, Annie J. Cannon at Harvard University examined thousands of stellar spectra. Without concern for the actual atmospheric gases or temperatures, Cannon classified each spectrum as A, B, C,. . . . S, depending on the number of absorption lines. Class A has few strong lines, class F has more, and classes M to S have bands, which are many lines close together, produced by molecules. Later studies showed that Cannon's classes are a measure of surface temperature (T_s) in the sequence O, B, A, F, G, K, M, R, N, S. This measurement is based partly on physicist Max Planck's formula, which gives the relative emissions of various colors from a hot body. A cool star emits most of its light in the red; a hot star emits most of its light in the blue. A measurement of the ratio of blue to red light coming from a star (its color index) determines its temperature. O stars are hot (T_s = 30,000 K); A stars have T_s = 10,000 K; G stars, such as the Sun, have T_s = 6,000 K; and M stars have T_s = 3,000 K. Other spectrographic measurements of absorption lines and emission lines help to confirm or modify this so-called color temperature.

From 1911 to 1913, Einar Hertzsprung and H. N. Russell first plotted the luminosity (L) versus the surface temperature (T_s) of stars, using as a measure of temperature the spectral types determined by Cannon. The HERTZSPRUNG-RUSSELL DIAGRAM first showed that highly luminous stars are mostly of classes O and B, with helium lines and T_s = 25,000 K, whereas low-luminosity stars are mostly of class M and T_s = 3,000 K.

Size. Once the temperature and the bolometric luminosity of a star are known, its size can easily be calculated. Planck's formula gives the total emission of radiant energy per unit area of a hot body's surface at each temperature. From the bolometric luminosity, the total energy emitted is known; from the temperature, the radiant energy emitted per square centimeter is known. The ratio gives the number of square centimeters, from which the radius of the star can be calculated. This rough calculation shows that the radii of stars vary from 1/100 of that of the Sun for WHITE DWARFS to 400 times that of the Sun for SUPERGIANTS. The radius of a nearby star can also be measured directly with an interferometer on a telescope. Astronomers theorize that objects with a starlike composition but too small to initiate nuclear reactions may also exist in the universe, helping to account for the "missing mass" of COSMOLOGY theories (see BROWN DWARF).

Mass. More than half of all stars are in binary (two-star) or multiple-star systems (see BINARY STARS). About 100 orbits in such systems have been measured accurately, providing perhaps the most important characteristic of a star: its mass. Using Newton's laws of gravitation, the mass of a star in a binary system can be calculated from its orbit size and the period of the orbit. If the binary stars eclipse each other, this situation also gives estimates of each star's diameter. Orbits of the planets show that the Sun's mass is 2×10^{33} g (2 billion billion billion tons, or about 333,000 times the Earth's mass). Orbits of binary stars show that some stars (giants) are 40 times the mass of the Sun, and others (dwarfs) only 1/10.

The mass of a star is also related to its luminosity; a high-mass star has high luminosity, and a low-mass star has low luminosity. The MASS-LUMINOSITY RELATION states that the luminosity is approximately proportional to $(\text{mass})^{3.5}$. A star twice the mass of the Sun will have luminosity $2^{3.5}$, or 11.3 times the Sun's. This fact, together with the temperatures and compositions of stars, is closely related to theories of stellar structure.

In addition to luminosity and binary-star orbits, two systematic features in the motions of stars relate to their masses. In many groups and clusters of stars, the stars have similar motions and similar Doppler shifts in the lines of their spectra (see RED SHIFT); these similarities are easy to pick out from the random motions of single stars. The smaller motions of stars within a cluster show the cluster's total mass—the sum of the masses of all the stars bound together in it by their gravitation. These internal motions can also be used statistically to determine the distance from Earth to the cluster.

Starspots. Starspots (cooler regions on the surface of stars, similar to the familiar SUNSPOTS) are now known to exist on a number of relatively nearby stars. The disks of such stars can be mapped to some degree to show areas of differing temperature, using the technique known as speckle interferometry (see INTERFEROMETER). The giant star Betelgeuse was observed in this manner as long ago as the mid-1970s. By means of spectral studies, astronomers have also been able to detect apparent granulation patterns on some stars. Such patterns on the Sun are produced by convection, or the rising and falling of hotter and cooler materials just below the visible surface. Analysis of stellar spectra to yield this kind of detail requires the use of supercomputers. A larger, different kind of surface variation on stars has been reported by some astronomers, who call these variations "starpatches."

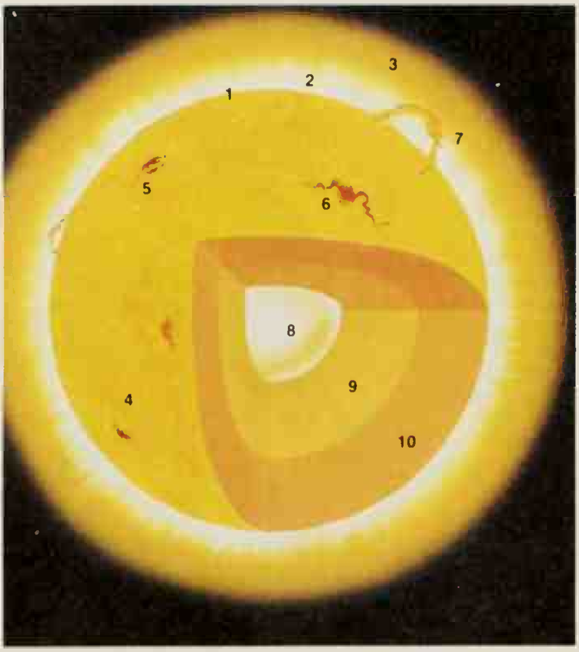
Structure of Stars

The structure of a typical star was worked out by astrophysicists after 1920, largely based on observations of the Sun. The photosphere is the visible surface of a star and is the layer to which the surface temperature and radius apply. Above the photosphere is an atmosphere, mostly transparent, where gases absorb characteristic lines in the spectrum and reveal the chemical composition of the star.

The temperature of the stellar atmosphere is lower than the temperature of the photosphere. Above the atmosphere is a transparent corona of diffuse gas at high temperature.

The knowledge of a star's internal structure is almost entirely theoretical, based on laboratory measurements of gases. Beneath the photosphere are several layers, some where the hot, ionized gas is turbulent, and some where it is almost at rest. Calculations of structure are based on two principles: convective equilibrium, in which turbulence brings the energy outward, and radiative equilibrium, in which radiation brings the energy outward. The temperature and density are calculated for each depth, using the characteristics of the mix of gases (hydrogen,

The Sun, a typical star, is a great sphere of burning gases. The photosphere (1) *is the surface that is normally visible. The chromosphere* (2) *and the corona* (3) *are transparent, upper atmospheric layers of low density. Constantly changing photospheric features include bright, grainlike patches, or granulations* (4), *sunspots* (5), *and dark, threadlike filaments* (6) *of exploding gases that appear as prominences* (7) *when seen on the solar limb. The energy emitted by the Sun comes from thermonuclear reactions within the core* (8). *The energy from the core flows out to the surface by radiation through a radiation zone* (9) *and by convection through a convection zone* (10).



helium, and heavier elements) derived from the spectrum of the atmosphere. The pressure is calculated from the weight of the gases overhead.

Eventually, deep in the interior the temperature and density are high enough (10,000,000 K and 30 g/cm^3) for a nuclear reaction to occur, converting four hydrogen atoms (4 ^{1}H) to one helium atom (^{4}He), with a 0.7% loss of mass. Because the conversion of this mass (m) to energy (E) follows Einstein's equation $E = mc^2$ (where c is the velocity of light), such a reaction releases 6.4×10^{18} ergs of energy per gram of hydrogen, 60 million times more than chemical reactions such as the burning of hydrogen in oxygen. It is this enormous source of energy that makes long-lasting and self-luminous stars possible.

In an attempt to determine the precise mechanism providing the energy for stars, physicists in the early 1930s measured the rates of several nuclear reactions in the laboratory. In 1938, Hans Bethe showed that the carbon-nitrogen cycle could account for a star's long-lasting luminosity. In Bethe's theory, carbon (^{12}C) acts as a catalyst in the conversion of hydrogen to helium. The small amount needed is converted to nitrogen (^{14}N), then converted back to carbon to be used again. The reaction rates at the temperature and density in the core of the Sun are fast enough to produce 10^{33} ergs/sec, the luminosity of the Sun.

Later it was shown that the proton-proton reaction could also produce the Sun's luminosity, by fusing hydrogen protons into helium, with the release of NEUTRINOS. More recent studies show that in the Sun and smaller stars, where temperature and density in the core are lower than in larger stars, the proton-proton reaction beats out the Bethe cycle and can occur with no ^{12}C or ^{14}N present, if the temperature is about 10,000,000 K. One of the great mysteries of modern astrophysics is the failure of experiments to detect the neutrinos expected from nuclear reactions in the Sun.

TABLE 1: THE NEAREST STARS

Name	*Distance (light-years)*	*Apparent Brightness (magnitude)*
Sun	—	–26.8
α Centauri A	4.3	–0.01
α Centauri B	4.3	1.33
α Centauri C	4.3	11.05
Barnard's Star	5.9	9.54
Wolf 359	7.6	13.53
Lalande 21185	8.1	7.50
Sirius A	8.6	–1.47
Sirius B	8.6	8.68
Luyten 726–8A	8.9	12.45
Luyten 726–8B	8.9	12.95
Ross 154	9.4	10.6
Ross 248	10.3	12.29
ε Eridani	10.7	3.73
Luyten 789–6	10.8	12.18
Ross 128	10.8	11.10
61 Cygni A	11.2	5.22
61 Cygni B	11.2	6.03
ε Indi	11.2	4.68
Procyon A	11.4	0.37
Procyon B	11.4	10.7

SOURCE: Adapted from a table compiled by Alan H. Batten in *The Observer's Handbook 1976* of the Royal Astronomical Society of Canada and a table in *Drama of the Universe* (1978) by George O. Abell (reprinted by permission of Holt, Rinehart and Winston).

TABLE 2: THE BRIGHTEST STARS

Name	*Constellation*	*Apparent Brightness (magnitude)*	*Distance (light-years)*
Sun	—	–26.8	—
Sirius A	Canis Major	–1.47	8.7
Canopus	Carina	–0.72	98
Arcturus	Boötes	–0.06	36
α Centauri	Centaurus	–0.01	4.3
Vega	Lyra	0.04	26.5
Capella	Auriga	0.05	45
Rigel	Orion	0.14	900
Procyon A	Canis Minor	0.37	11.3
Betelgeuse	Orion	0.41	520
Achernar	Eridanus	0.51	118
β Centauri	Centaurus	0.63	490
Altair	Aquila	0.77	16. 5
α Crucis	Crux	0.87	400
Aldebaran	Taurus	0.86	68
Spica	Virgo	0.91	220
Antares	Scorpius	0.92	520
Fomalhaut	Piscis Austrinus	1.15	22.6
Pollux	Gemini	1.16	35
Deneb	Cygnus	1.26	1,600
β Crucis	Crux	1.28	490

SOURCE: Adapted from a table compiled by Donald A. MacRae in *The Observer's Handbook 1976* of the Royal Astronomical Society of Canada and a table in *Contemporary Astronomy*, 2d ed., by Jay M. Pasachoff, Holt/Saunders, 1980.

Whether by the Bethe cycle or by the proton-proton reaction, the Sun and other stars are converting hydrogen to helium in their cores at a considerable rate (600,000,000 tons/sec in the Sun). Because helium has different characteristics, this conversion changes the structure of the star. During the process there is a central core composed entirely of helium, a spherical shell around it in which hydrogen is being converted to helium, and the rest of the star, composed mostly of hydrogen. When a large core of helium has been created, the core may collapse, and new nuclear reactions may start as the temperature and density jump to very high values. When the temperature exceeds 100,000,000 K, helium is converted to carbon. Astrophysicists make use of the Hertzsprung-Russell diagram and large computers to calculate how stars evolve in this way. They find that stars of different masses evolve in different ways and at different rates. The most massive stars (ten times the Sun's mass) rapidly change from blue giants to red giants and may become unstable and pulsate as variable stars during this stage. Stars of lesser mass, such as the Sun, spend a large fraction of their lives on the main sequence of the Hertzsprung-Russell diagram while they convert hydrogen to helium. After several billion years, these stars become white dwarfs. Depending on mass and other circumstances, a star may evolve to a NOVA or SUPERNOVA, PULSAR, NEUTRON STAR, or BLACK HOLE (see STELLAR EVOLUTION).

star-of-Bethlehem Star-of-Bethlehem is the common name for several species of the genus *Ornithogalum* of the lily family, Liliaceae. Native to Europe, *O. umbellatum* is bulbous, with linear leaves reaching 30 cm (1 ft) in length. The flower stalks support up to 20 starlike flowers, predominantly white.

Star Chamber Star Chamber, an English court of law active in the Tudor and early Stuart periods, was abolished by the Long Parliament in 1641. An outgrowth of the royal council, it was made up of privy councilors as well as judges and supplemented the activities of the common-law and equity courts in both civil and criminal matters. Initially well regarded because of its speed and flexibility, Star Chamber became unpopular as the Stuart kings used it with increasing arbitrariness to enforce the royal prerogative. Its name thus became synonymous with secret, irresponsible court proceedings.

Star of David The six-pointed Star of David, called in Hebrew *Magen David* ("shield of David"), is the accepted symbol of Judaism. It is incorporated in the center of a white background to form the flag of the modern state of Israel. The Red *Magen David* is used in Israel to designate the equivalent of the Red Cross.

Star-Spangled Banner, The The music of "The Star-Spangled Banner" was composed in 1777 by John Stafford Smith, an Englishman, as a setting for the poem "To Anacreon in Heaven," to be sung by members of a social club in London called the Anacreontic Society. The original song celebrates the joys of music, love, and wine. The melody quickly arrived in the United States and was used with alternate words, the earliest-known version being written by Francis Hopkinson in about 1790; by 1820 there were 84 different poems being sung to the Anacreontic melody.

The words of "The Star-Spangled Banner" were written by Francis Scott Key on Sept. 14, 1814, inspired by the sight of the U.S. flag at Fort McHenry withstanding a nightlong bombardment from an offshore British warship. He indicated that the words were to be sung to the Anacreontic song, a melody he had used nine years earlier for another poem. "The Star-Spangled Banner" attained popularity quickly but was no more prominent as a patriotic air than "Yankee Doodle" or "Hail Columbia." During the Civil War it was adopted informally as an anthem by the Union Army, and it was adopted officially by the U.S. Army during World War I. It did not become the U.S. national anthem, however, until signed into law by President Herbert Hoover on Mar. 3, 1931.

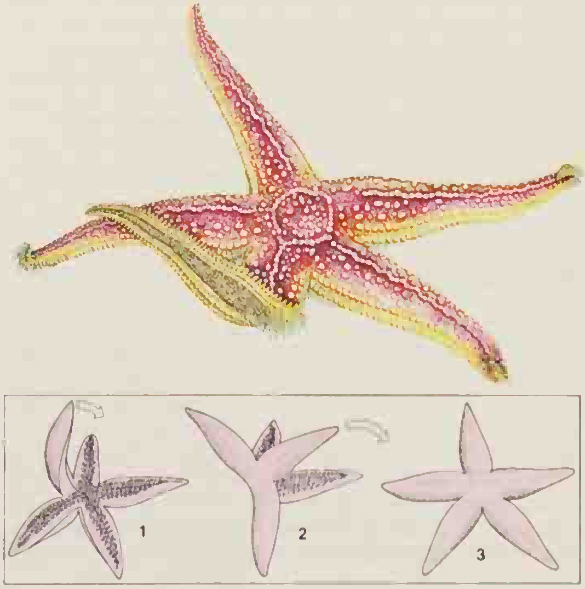
Star Wars see Strategic Defense Initiative

starch Starch is a natural organic polymer manufactured by green plants through photosynthesis to serve as a metabolic reserve. It is therefore classified as a nutrient POLYSACCHARIDE, in contrast to similar CARBOHYDRATE structures that are used for support. Nearly all starch is a mixture of two different kinds of carbohydrate, termed *amylose* and *amylopectin*. Starch occurs in the form of grains in many parts of the plant, principally in embryonic tissues such as seeds, fruit, roots, and tubers. Plant starches are important sources of energy in the diets of humans and other animals.

The most important U.S. manufactured starch is cornstarch, which can be hydrolyzed for the manufacture of *D*-glucose and corn syrup. About one-third of the total cornstarch and 95% of the corn syrup produced are sold for food purposes. For industry, the properties of most starches are changed by chemical treatment or enzyme action. Modified starches are used in adhesives; for textile, paper, and leather sizing; and as binders in sand molding.

starfish Starfish, or sea stars (class Asteroidea, phylum Echinodermata), are radially symmetrical invertebrates with usually 5 but up to 20 or more short or long rays, or arms, radiating from a central disk. Each ray is an extension of the body cavity and the vital organs. The group is worldwide and ranges from the seashore to depths of 6 km (3.7 mi). Most starfish are 10–30 cm (4–12 in) in diameter, but *Midgardia xandaros* exceeds 1 m (3.3 ft) in diameter.

A common starfish can right itself if it is on its back (bottom, left to right). *First, it twists one arm* (1), *moving the arm until the body folds over* (2), *then turns right side up* (3).

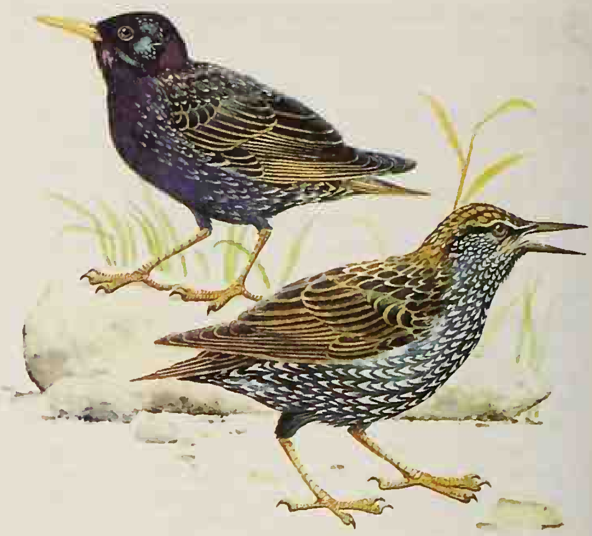


The starfish body is sheathed in a flexible armor of skeletal pieces, or ossicles. From the central mouth on the underside of the body, channels with two or four rows of tube feet (suction cups present or absent) radiate outward along the arms. If present, the central anus is found on the upper surface, where a circular sieve plate, or madreporite, opens into the water vascular system, a hydraulic system that moves the tube feet. Each arm has a sensory tentacle that responds to various stimuli, and a red photosensitive eyespot located at the tip of the arm. Starfish vary greatly in color. Bilaterally symmetrical, swimming larvae result from external fertilization. The larvae metamorphose into free-living adult forms.

Most starfish are predators or scavengers. Predatory forms favor bivalve mollusks; they open them slightly by the pulling action of the sucking tube feet and then digest the soft parts externally. They frequently devastate oyster and clam beds, and some cause extensive damage to coral reefs.

stargazer Stargazers, family Uranoscopidae, comprise about 25 species of sluggish fishes that lie in the sand of ocean bottoms waiting for prey. Small eyes near the front of their heads point upward. Fleshy flaps keep sand from their large mouths. These fish may also resemble worms or other food and thus attract prey, which is then engulfed. Well equipped for defense, stargazers produce electric charges as strong as 50 V from modified optic nerves, and above their pectoral fins they have two poison spines, each with a venom gland at the base. Body length averages about 20 cm (8 in).

Stark, John John Stark, b. Londonderry, N.H., Aug. 28, 1728, d. May 8, 1822, commanded American troops in the American Revolution. During the French and Indian War he served with Rogers's Rangers. As colonel of a New Hampshire regiment, Stark fought in the battles of Bunker Hill (1775), Trenton (1776), and Princeton (1777). Promoted to brigadier general, he gained fame by defeating units of Gen. John BURGOYNE's army near Bennington, Vt., on Aug. 16, 1777. Two months later Stark became a brigadier general in the Continental Army.



The starling S. vulgaris *has white speckles in winter* (foreground) *and a yellow bill in summer* (background).

starling Starlings, members of the bird family Sturnidae, are perching birds that number more than 111 species, including the MYNAH. Ranging from 18 to 43 cm (7 to 17 in) in length, they are highly sociable, and many are good mimics. The most common color is black, and the plumage is often glossy. Those in temperate areas migrate part of the winter, often in huge flocks, which can be quite noisy. Although they are tree birds, starlings readily seek food on the ground. The clutch size is three to six eggs, and the eggs are laid in tree and wall holes. The common starling, *Sturnus vulgaris*, native to Eurasia, has become widely established and has reached nuisance abundance in some areas, often driving out other birds. Starlings, however, are of some value in destroying insect pests and parasites.

Starr, Bart Bryan Bartlett Starr, b. Montgomery, Ala., Jan. 9, 1934, was an American professional football player who helped turn a floundering team, the Green Bay Packers, into one of the greatest clubs in league history. After playing as a quarterback at the University of Alabama, he joined the Green Bay Packers of the National Football League (NFL). During his 16-year career he guided the Packers to 6 division, 5 league, and 2 Super Bowl championships. Starr played in the NFL Pro Bowl 4 times (1960–62, 1966) and was named the Most Valuable Player in both Super Bowl appearances. After retiring he became an assistant coach (1972) for the Packers, and in 1975 he became head coach of that organization. Starr was inducted into the Pro Football Hall of Fame in 1977.

Starr, Belle Belle Starr, originally Myra Belle Shirley, b. Carthage, Mo., Feb. 5, 1848, d. Feb. 3, 1889, was an American outlaw. During the U.S. Civil War she provided Confederate guerrillas with information about the movements of federal troops. She later joined the outlaw gang headed by William C. QUANTRILL. In 1880 she married Sam Starr, who was of Cherokee and Irish extraction. Their home in Indian Territory in Oklahoma became notorious as an outlaw retreat. Belle Starr was shot and killed by an unknown assailant.

Starr, Ringo see BEATLES, THE

starvation Starvation is a syndrome, or abnormal state, that results from a quantitatively inadequate food intake or from a failure to properly metabolize food energy. In contrast, malnutrition is generally due to poor diet and results from deficiencies of particular nutrients (for example, iron deficiency leading to anemia). Starvation manifests itself first by weight loss and body wasting, and if unrelieved it may progress to emaciation, diarrhea that is difficult to treat, secondary infections, and eventually death by heart failure. Humans may die of cold in a few hours, or of thirst in a few days, but they usually die of hunger only after weeks of starvation.

Starvation may have several causes. Starvation among large groups of persons most commonly results from FAMINE. Starvation in individuals may be secondary to certain diseases, most notably those which affect consumption, absorption, or proper metabolism of food. It may also result from food deprivation, such as during incarceration or when an abusive parent starves a child. Another form of starvation occurs in those who suffer from the disease ANOREXIA NERVOSA.

Starvation leads first to the wasting away of fat deposits. After most of the body's fat reserves have been burned up, there may be progressive wasting of muscles and reduction in size of body organs. As starvation progresses, changes in the intestines lead to poor absorption of nutrients and diarrhea. Blood pressure falls and the pulse slows. Edema may occur. Psychological changes such as apathy or irritability are common. In children marasmus or KWASHIORKOR may develop. The appropriate treatment depends on the severity of the starvation and on any underlying disease.

Stassen, Harold E. [stas'-en] When only 31, Republican Harold Edward Stassen, b. W. Saint Paul, Minn., Apr. 13, 1907, became (1938) the governor of Minnesota and held that office until 1943, when he resigned to join the navy for service in World War II. In 1948 he was narrowly defeated by Thomas E. Dewey in a campaign to win the Republican nomination for president. Since then, Stassen has campaigned unsuccessfully for the presidential nomination many times. He has practiced law privately, served (1949–53) as president of the University of Pennsylvania, and held several top appointive posts in the federal government.

state (political unit) The state is a political unit that possesses a territory, a population, a GOVERNMENT, and SOVEREIGNTY (or independence). All officers and organs of government—legislative, executive, judicial, and administrative—are creations of the state.

The term *state* is used in another sense in a federal system such as the United States—to refer to one of the 50 semiautonomous political entities that coexist with the federal (or national) government. In the United States some powers belong exclusively to the national government, some belong to the states, and others are shared by both. The 10th Amendment to the U.S. Constitution reserves all powers to the states that are not given by the Constitution to the federal government, nor denied by it to the states.

state (in political philosophy) The state is frequently defined as the highest or most comprehensive political association having a recognized claim to primacy—first allegiance or ultimate authority. According to another common definition, statehood is the stable possession of preponderant power by a single authority within a delimited territory. Two impediments, however, stand in the way of any simple definition of the state. The first is that the term has been used quite loosely, to designate any sort of political rule at any period in history ("the Byzantine state," "the Papal states"); and at the same time quite restrictively, to designate the kind of political structure mainly characteristic of post-Renaissance Western societies. The second impediment is that notions about what the state is vary systematically with the various political philosophies: a Lockean liberal who advocates a minimalist state that merely enforces natural law and protects natural rights will never be able to agree with a Hegelian that the state is the concrete actualization of rational freedom on earth, or with a Marxian that the state is a mere committee for the management of the interests of the social class owning the means of economic production. Defining the state is not easy unless one is prepared to declare dogmatically that a particular theory of statehood is correct, to the exclusion of all others. The same difficulty afflicts any effort to say what the state's purpose is. A Benthamite utilitarian will urge that the end of the state is the greatest happiness of the greatest number, and that the pursuit of this end gives the state legitimate authority. A Kantian will suggest that the state exists to provide a legal context within which good will and respect for persons is more nearly possible.

Nor is the tracing of the origin of the state free of this same difficulty: some have traced the foundation of the state to a desire for security and peace (Thomas HOBBES); some have insisted on natural sociability as creating states, believing that the stateless human is either a beast or a god (ARISTOTLE); some have put forward economic motives such as a desire for the division of labor and an economy of scale, which can be obtained only by centralizing power and authoritatively allocating work (Edmund BURKE); still others have stressed human depravity in a fallen world creating the need for the state (Saint AUGUSTINE). In trying, then, to say what the state is, what its purposes are, and where its origin is, the problem always exists that the state is itself not simply a fact but a conceptual artifact. The most reasonable and candid way to treat the state, therefore, is to offer a history of theories about it.

Characteristics of the State. The word *state* is ultimately traceable to the Roman legal idea of *status civilis*, or "the civil condition"; at the greatest level of generality *state* does indeed mean "condition" or "way of being" ("the state of one's health"). The use of the English term

Saint Augustine articulated his Christian philosophy of history and political theory in The City of God *(413–26). He interpreted human history as a conflict between two mystical cities, the City of God (those destined for salvation) and the Earthly City (the damned). The function of the state is to provide stable conditions in which people may work toward their salvation.*

state in its specifically political sense first became current around the 16th century—in England rather later than on the Continent, where the French *état* and Italian *stato* were in use soon after 1500 (by Nicolò MACHIAVELLI, for instance). The modern term *state* was usually accompanied by the notion of SOVEREIGNTY. The ideas of state and sovereignty are intimately related; they arose together historically and still make most sense when juxtaposed. Most—although not all—political philosophies would concur that sovereignty is the hallmark of the state.

In a general attempt to identify state characteristics that would be recognized by a substantial number of political philosophies, one can say that the state is separated conceptually and historically from other kinds of political rule by (1) its extreme centralization or concentration of power internally, coupled with its rejection of so-called supranational power externally; (2) its secularism, or at least its nonreligious basis, necessitating, at a minimum, toleration of religious diversity; (3) its emphasis on the legal rights of its citizens rather than on the direct participation of all in day-to-day decision making; (4) its reliance on the authority of LAWS that it makes, interprets, and enforces itself through its own agents; (5) its operation—once law is in effect—through a bureaucracy, or civil service, that exists mainly to perform services for the public; and (6) its refusal to leave decisive portions of power with any private or voluntary association, such as a church or a corporation.

The theory of state sovereignty explains and defends—opponents would say rationalizes—the historical process that is thought to have taken place in early modern European history: the removal of power from subnational groups and from supranational institutions. State sovereignty can be contrasted with tribal rule, theocratic rule, patriarchal rule, rule by plain violence, or nonrule by spontaneous consensus (ANARCHISM), as well as with FEUDALISM.

Early Development of the Concept of the State. Whether the Greek polis or CITY-STATE, as theorized by Aristotle in the 4th century BC, was really the forerunner of the modern state, is a subject of endless dispute. Some political philosophers, stressing the notion that the polis was an ethical community for the attainment of virtue or goodness, have insisted that the polis was as much a church as a state. Others have argued that Aristotle invented the idea of the state as a public, secular, and legal order.

The Aristotelian polis would be a city with a large middle class that would promote stability and balance the conflicting claims of the poor and the rich. The city's constitution would combine elements of democracy with elements of aristocracy (again, to balance opposing claims); the distribution of scarce and valuable goods would be in proportion to contribution to the good of the polis; the citizens would rule and be ruled in turn, insofar as the mixed social system allowed. The rule of law would prevail, moderated by equity in meeting individual claims. Above everything else, a spirit of moderation would prevail. Some of this theory resembles modern ideas about the state: like Hobbes and Immanuel KANT, Aristotle insists on the centrality of the rule of law. Like G. W. F. HEGEL, he insists that a substantial middle class will help produce a moderate, stable polity; like Machiavelli, he draws distinctions between what is ideal and what is best in a given set of circumstances. Even so, Aristotle's notion that "any polis which is truly so called must devote itself to the end of encouraging goodness," that a true city must not be a mere alliance or covenant that guarantees "men's rights against one another," separates him from much of modern state theory.

The State in Roman Thought and Practice. The theoretical attributes of a state—extreme centralization, secularism, legal rights rather than participation, the rule of law, bureaucracy, the divesting of lower associations of their power—were first to be found in a fairly full form in Roman theory and practice. A great deal of the structure of the state as well as theory of sovereignty itself is of substantially Roman origin. Rome exemplified many characteristics of the state. Its internal power, particularly within Italy, was highly centralized, and its external power was all but unshakable for centuries. It was not truly a secular power, but its toleration of dozens of sects promoted considerable harmony. Its emphasis on the legal rights of its citizens was of great importance. Rome's maintenance of services (courts, roads, water supplies, a postal system) administered by a trained bureaucracy pointed the way to the modern state. Finally, a genuine political rule prevailed—at least before the ultimately fatal militarization of the empire. Rome did not leave vast power to groups within society.

Rome's reliance on the rule of law gave great importance to courts, to lawyers, to precedent, and to process; moreover, Rome made, interpreted, and enforced its own laws through its own agents. The Romans virtually invented legal philosophy (see LAW, HISTORY OF), or jurisprudence. The distinction between the *ius naturale* (NATURAL LAW), the *ius civilis* (CIVIL LAW), and the *ius gentium* ("law of nations") is largely a Roman invention. The expression of sovereignty through law—very much a Roman idea—is decisive for many later theories of state sovereignty.

The State in Medieval Thought and Practice. The fall of the Roman Empire led, in most views, to the fairly rapid atrophy of the state method of governance and finally to feudal fragmentation. It is usually thought, although on widely differing grounds, that the notions of internal and external state sovereignty began to revive a little in the later Middle Ages, at the beginning of the 14th century. The French monarchy had long claimed its temporal independence from the Holy Roman Empire, which was often supported by the papacy. In political philosophy the rediscovery of Aristotle's doctrines did much to enhance the prestige of temporal government and to weaken the Augustinian view that politics, as a consequence of the Fall, ought to give way to the earthly agents of the Heavenly City.

Aristotle as a political writer was fully resuscitated by MARSILIUS OF PADUA's *Defender of Peace* (1324; Eng. trans., 1535), which quotes Aristotle's *Politics* approvingly at every turn and treats political secularism, or civil government, as wholly respectable. By the 14th century, in any event, the conditions for the theory and practice of state sovereignty were coming back into existence.

The doctrine and the exercise of sovereign power by states can be seen not only as the recovery of antiquity and as an escape from the papacy and the Holy Roman Empire, but also as a liberation of individuals as well as of whole nations from the increasingly outdated prerogatives and private laws (*privi leges*) that had come to intervene between individuals and civil authority in the Middle Ages. The destruction of the Western Empire and the subsequent insecurity of about 800 years saw a number of nonpolitical public authorities develop between individuals and the shadowy central authorities of the Middle Ages. Anyone who could manage both to pacify and to control a sizable piece of territory thereby became a landlord. By defending the inhabitants on his lands and by swearing feudal allegiance to a higher authority, he would enjoy political control of those individuals under his protection.

Thus, the private prerogatives of the landlord were extended to public authority. At every level the church, which had replaced the defunct Roman state in all matters touching public morality, preservation of culture, and education, exercised enormous public authority. And on top of the secular and ecclesiastical hierarchies within any particular country were the "universal" authorities, the emperor and the pope.

The doctrine of the sovereign state could act as a liberating agent by destroying the system of private rights acting as public laws. The development of a theory of supreme political power was a happy way to get out from under the various prerogatives of feudal nobles, prelates, guilds, and corporations. After the Reformation the doctrine of state sovereignty became particularly attractive as a secular rallying point for those who were looking for a new, nonreligious principle of social unity to end religious civil wars.

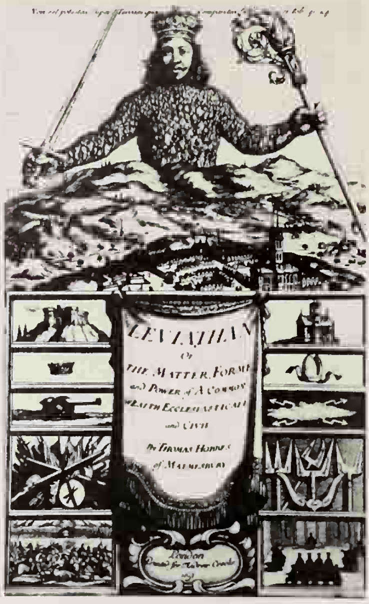
By the 16th century doctrines of internal sovereignty had gradually begun to triumph. By then the doctrine of external, or international, sovereignty was perhaps even more advanced. The idea of universal authorities was no longer plausible. The Reformation definitively ended the universal authority of the pope, but it also dealt a crippling blow to the vestiges of the emperor's universal credit.

The Modern State. Nicolò Machiavelli (1469–1527) is commonly treated as the first modern political thinker, and sometimes as the first political scientist. His notion of rule was highly personalistic, however, and in fact, his notion of the creative use of personal talent seems closer to the Florentine Renaissance than to the sobrieties of Hobbes or Hegel.

The first generally recognized theorist of state sovereignty was the French writer Jean BODIN. Bodin defined the state as an authoritative power that can "give laws unto all and every one of its subjects and receive none from them": the state is supreme, not merely one among other lawgiving public authorities. Although Bodin's sovereign was to be above the positive or civil law because he was the law's creator, he was still subject to divine and natural law; the sovereign was also to respect the fundamental constitutional laws of his realm, as well as his subjects' property rights. In short he was—although the highest and the final authority—a lawgiving authority, not an arbitrary or capricious one. Bodin was the first to conceive an absolute political power in this sense. States, for Bodin, are as independent externally as they are supreme internally, and he went on to formulate a theory of international dealings by treaties between sovereign states.

Thomas Hobbes took the doctrines of internal and external state sovereignty to their limits. The Hobbesian sovereign (what he called the "Leviathan"), who absorbed by virtue of the SOCIAL CONTRACT all the natural rights of his subjects save self-defense, was an absolute lawgiver in the strictest sense. For Hobbes neither morality nor any kind of law exists before it is willed by a sovereign to whom subjects are obligated by a contract of obedience. The Hobbesian sovereign, then, is the creator not only of positive law but of standards of right and wrong, of a civil religious doctrine, and even in part of public opinion. Moreover, if, as Hobbes asserted, the state creates morality and law and humans must submit to it for their self-preservation, then all justice will exist only within closed single-state systems, and the relations between those states, existing in a moral and legal void, will be like the relations between humans before the social contract. The very creation of a supreme state, then, implies the possibility of its hostility to other similar states if medieval natural law and the Roman *ius*

Nicolò Machiavelli, considered the first modern political thinker, is best known for the theories of government expressed in The Prince *(1513) and in* Discourses on the First Ten Books of Livy *(1513–21). Both works are notable for their advocacy of expedient policies in government. (Palazzo Vecchio, Florence.)*



The title page from Thomas Hobbes's Leviathan *(1651) portrays the sovereign as the absolute ruler of his subjects. In this famous work Hobbes showed how the political power of the state could be rationalized, and defended the existence of an absolute government that protects its individual subjects, who are obligated to their sovereign by a contract of obedience.*

gentium are discarded. For Hobbesians, the doctrine of internal sovereignty gives rise by logical necessity to external sovereignty. States, then, being perfectly independent, can be bound only through their own wills, that is, in the same way that individuals are bound to a particular state, through contract or treaty. At this point modern ideas of international relations begin. Henceforth the recognized, political unit is the state, and relations between these states take the form of treaty relations.

The greatest "statist" after Hobbes was G. W. F. Hegel. For Hegel the modern state was "mind on earth," the "great hieroglyph of reason," the concrete realization of rational freedom. The Hegelian state is not a mere monolith: the Hegelian state is a monarchy moderated by the law-drafting functions of disinterested civil servants and moderated above all by the Hegelian notion that individuals must be able to find subjective satisfaction in their being willing members of a rational, free institution that secures the pursuit of absolute values inherent in philosophy, art, and religion. Even in Hegel—usually seen as the theorist of the modern state par excellence—sovereignty and concentrated power is not all that matters; the state must be instrumental in the pursuit of philosophy, art, and religion.

The Limited State. A formidable concentration of sovereign power was never, in fact, the sole (although it remained the primary) attribute of statehood. If even statists could imagine limiting the state others were able and willing to conceive much stronger limitations. Hobbes's greatest immediate English successor, John LOCKE, carefully refrained from using the terms *state* and *sovereignty* at all. Because he saw government as the rule of an impartial judge, set up by voluntary agreement, who simply enforces God-given natural law and defends natural property rights earned by mixing one's labor with the world, Locke's idea of the state was extremely limited. The already slender Lockean state is further limited by the fact that the legislative branch is representative—and hence amenable to popular control (see REPRESENTATION)—and by the Lockean right of revolution, which can be used by the people to bring down a government that fails to preserve natural law and rights. In Locke, then, there is a balance between the state and what can be comprehensively called society; this balance is usually styled the liberal notion of the state.

The most celebrated advocate of a state-society balance is Baron Charles de MONTESQUIEU. Montesquieu argued that if states are to be moderate and avoid Oriental despotism, central power must flow through, and sometimes be checked by, such intermediate bodies as parliaments, the regional nobility, and the church.

If Locke wished to limit the state in order to protect natural law and rights, and Montesquieu to preserve moderation and liberty, a utilitarian like Jeremy BENTHAM had different reasons for limiting the scope of state power. According to Bentham, the operation of the state must be at least somewhat painful, because the state's general measures do not and cannot maximize the particular pleasure (utility) of each actual individual. This was sufficient reason for Bentham to limit the state, which he thought should confine itself principally to controlling those pains which are more hurtful—murder and robbery, for example—than the activity of the state itself.

Still different reasons for state limitation were adduced by 19th-century liberals such as Alexis de TOCQUEVILLE and John Stuart MILL, who agreed that the democratization of politics and the state following the French Revolution and the Industrial Revolution, coupled with the new influence of public opinion, could lead to a possible "tyranny of the majority." Both de Tocqueville and Mill were led to advocate a new kind of aristocracy—not feudal aristocracy, but the leadership of those who, according to Mill, "stand on the higher eminences of thought." According to this view, public power had to be limited because the new democratic public had become potentially dangerous.

The State Eliminated: Marxism, Pluralism, Political Science. For the much more radical 19th-century theorists, what the state needed, they felt, was not limitation but elimination. Karl MARX, for example, viewed the state as an "epiphenomenon," or "reflection," of a given all-important economic substructure of society. For Marx, then, the state should and will "wither away"—not merely be limited or reformed. One need not, of course, be a Marxist to be hostile to the idea of the state. For Ernst CASSIRER, a Kantian liberal, the "myth" of the state had led to the worship of concentrated power, culminating in FASCISM. A modern pluralist such as John N. Figgis (1866–1919) insists that the notion of state sovereignty is no more than a venerable superstition, a vestigial relic of Tudor pretensions, and that social life is a "series of groups," all of which have some life of their own not merely granted by the state. Arthur Bentley (1870–1957), an immensely influential modern political scientist, argued that whereas the idea of the state has been "very prominent ... among the intellectual amusements of the past," it is not really true that the state is a kind of "crystallization" of authoritative power; politics for Bentley is a matter of self-interested groups attempting to determine the behavior of other people and other groups. Even if a group seizes the governing apparatus, what still matters is the group and its interests. For H. L. A. HART, perhaps the most eminent post–World War II legal theorist, it is unreasonable to begin political thinking with the state: it is at least as valid to start with voluntary associations or with the international community and then to ask what is left for the state.

Much of recent political science, concerned with groups, interests, and processes, has tended to further erode the importance of the concepts of state and sovereignty. In systems theory, for instance, what matters is the whole interactive political system: its "inputs," its "outputs," and its "transactions." The state, then, is today no longer the central concern of political study. Even when dealing with a modern social scientist who is largely sympathetic to the state—for example, Max WEBER—one still finds a tendency to reduce the state to rational bureaucracy alone.

Most modern humans share a view of the state's necessity that roughly approximates Frederick Watkins's (1910–72) elegant formulation that the "whole structure of modern civilization would inevitably collapse in the absence of those conditions of ordered peace that have been ensured through the integrating activities of the sovereign state." This does not, however, settle what modern civilization and the sovereign state are worth—whether they have a value equal to the cost (in every sense) of realizing them. This uncertainty reinforces, therefore, the idea that states—especially with respect to their purpose—are in part only artifacts of political visions.

State, U.S. Department of The oldest federal department in the United States, the Department of State is responsible under the president's direction for the conduct of foreign policy. The secretary of state is the senior cabinet official. The department negotiates treaties, represents the United States in foreign countries and in international organizations, and recommends and implements policy.

Created by Congress as the Department of Foreign Affairs on July 27, 1789, and given its present name on Sept. 15, 1789, the department, under its first head, Thomas Jefferson, was given various domestic responsibilities in addition to the conduct of foreign policy. The domestic tasks were eventually shifted to other departments.

During and after World War II both the department's domestic and foreign staffs were greatly increased, and the department was given new functions fitting the U.S. position of world leadership. From 1945 to 1950 the continually expanding department added the Policy Planning Staff, the Bureau of International Organization Affairs, and the Bureau of Economic Affairs.

See also: FOREIGN SERVICE.

state rights The term *state rights*, or *states rights*, is used to describe the actual or assumed privileges granted to individual states under the U.S. Constitution. The 10th Amendment (part of the Bill of Rights), ratified in response to protests that the main body of the Constitution did not adequately protect the rights of the states, reflected both the traditions of colonial self-rule and the experiences of the American Revolution, which bred distrust of a centralized authority unfamiliar with local needs and problems. The amendment specifies that those "powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively, or to the people." Even with the addition of the amendment, however, the Constitution defines the boundary between federal power and state rights only in very broad, general terms. A more precise definition has thus been a perennial constitutional issue. Advocates of state rights have traditionally advocated Thomas Jefferson's strict constructionist interpretation, which allows the federal government only those powers explicitly enumerated in the Constitution. Proponents of a more active and centralized federal government have followed Alexander Hamilton's loose constructionist interpretation of the Constitution, which grants to the central government broader implied powers.

Prior to the Civil War the Democratic-Republican party and the Jacksonian Democrats generally called for strict respect of state rights, and the Federalist, National Republican, and Whig parties advocated a more active role for the federal government. The Southern states, fearful of federal interference with slavery, were the most dogmatic in their use of state-rights doctrine. In the late 19th century, however, the state-rights precept was embraced by business interests as a means of resisting federal regulation, and liberal political movements abandoned strict constructionism in favor of government intervention to protect farmers, laborers, and minority groups. The state-rights doctrine was also invoked in the 1950s and '60s by opponents of federal civil rights legislation.

See also: KENTUCKY AND VIRGINIA RESOLUTIONS; NULLIFICATION.

Staten Island [sta'-ten] Staten Island, coextensive with Richmond County, is a borough (called Richmond Borough until 1975) of New York City. About 23 km (14 mi) long and 11 km (7 mi) wide, it has an area of 150 km^2 (58 mi^2). The population is 378,977 (1990). Located in New York Bay, 8 km (5 mi) south of Manhattan, Staten Island is linked to Manhattan by ferry, to Brooklyn by the Verrazano-Narrows Bridge, and to New Jersey by three bridges. The highest point is Todt Hill (125 m/409 ft). Manufacturing, shipbuilding, petroleum refining, and metalworking make the island an important industrial center. Algonquin Indians lived on Staten Island when the Dutch arrived in 1661. It was incorporated into New York City in 1898.

States-General The States-General, or Estates-General, was a national elective assembly representing the social "estates," or orders, in France and the Netherlands from the 14th to the 18th century. In France the first estate was the clergy; the second estate, the nobility; and the third estate, the middle-class commoners. The French assembly, commonly called the Estates-General, met occasionally between 1302 and 1789 whenever the monarchy needed a broad base of support to overcome fiscal or political crises, but it never advanced from advisory status to control royal taxes or policy on a regular basis. It was not summoned after 1615 until the FRENCH REVOLUTION, when the financially bankrupt LOUIS XVI called an assembly in 1789; its third-estate delegates forced the alteration of traditional voting by order to "vote by head," thereby transforming that last French Estates-General into a modern, democratic legislature.

The States-General of the Netherlands met regularly after 1464 to approve the taxation and foreign policies of the ruling Burgundian and Spanish dynasties. The revolt of the northern Netherlands made the States-General the Dutch Republic's governing body from 1579 to 1795, while it disappeared from the southern Spanish Netherlands (modern Belgium).

static *Static* is the collective term applied to the various forms of audible interference that are commonly superimposed over the communications heard through telephone and radio receivers. The sounds range from random crackling and popping to hissing, rushing, and humming.

Static may be caused by both natural and technological processes, and its sound often provides helpful clues as to its origin. Lightning produces the most noticeable and dramatic form of static. A nearby electrical storm can block the reception of an AM radio receiver with a series of loud crackles, pops, and crashes. Distant electrical storms and the natural discharges of static electricity in the atmosphere produce a variety of background noises and rushing sounds. Electromagnetic signals emitted by the Sun can also produce static disturbances in a receiver.

Static from nonnatural sources is generally a by-product of an electrical spark. A sparking contact produces a wide range of electromagnetic frequencies that are heard on AM receivers as popping or crackling sounds. Defective light switches and thermostats are common sources of such static. Certain kinds of direct-current electrical motors produce static with a whirring or whining sound. The static is caused by the spark discharge between the motor's brushes and commutator and can be transmitted to a radio or television through the air or over power lines. The high-voltage discharge at the spark plugs of an internal combustion engine of an automobile or other vehicle is another cause of static.

See also: NOISE.

static electricity see ELECTRICITY; ELECTROSTATICS; LIGHTNING

statics Statics is the study of the interactions of force and matter under equilibrium conditions, for which no acceleration occurs. Statics and dynamics (the study of force, mass, and motion) combine to form the field of mechanics, which is the oldest branch of PHYSICS. The principles of statics apply to all matter, whether it be solid, liquid, or gaseous.

Statics presupposes the condition of equilibrium, which means that all forces and torques on a body are balanced by equal and opposite forces and torques. Under such conditions, accelerations—both linear and rotary—are impossible according to Newton's LAWS OF MOTION. The establishment of equilibrium therefore requires that the object under study be either at rest or in a state of uniform linear motion.

Various stability criteria may be applied to the equilibrium condition. For example, a ball resting inside a round bowl is in stable equilibrium, for it returns to its original position when displaced. If the bowl is inverted, however, and the ball placed on top, it is now in unstable equilibrium, because the slightest disturbance will cause it to roll away. Intermediate to these two criteria is neutral equilibrium, represented by a ball resting on a flat surface.

The same approach is used to solve all problems in statics; all of the forces and torques acting on a system are summed, and the total must equal zero. An unknown quantity may be calculated if the values of the other quantities are known. A simple case is that of an object hanging on a rope. The only forces involved are F, the downward pull of the Earth, equal to the object's weight, and $-F$, the upward pull of the rope. F and $-F$ are equal in magnitude and opposite in direction; their sum is zero.

If an object is supported by two ropes attached to different supports (as, for example, a hammock), the problem is more complex because the forces do not act in a line. Each rope pulls at an angle. To find the tension in each rope, the force must be treated as a vector quantity and divided by the rules of VECTOR ANALYSIS into horizontal and vertical components. The sum of the horizontal components (one to the left and one to the right) is zero, and the sum of the ropes' vertical components (upward) plus the weight (downward) is zero. From these data can be found all the forces that act on the system.

The same method is used to solve problems of navigation involving the effects of wind and current on the paths of airplanes and ships.

Forces may generate a torque, or turning movement. In many situations, counteracting a torque is desired to prevent twisting, and this process can be done only with another equal and opposite torque. A torque is also called a moment of force and is defined as the product of the force times the perpendicular distance to the axis of rotation. A positive sign is customarily assigned to torques acting to cause counterclockwise rotation, and a negative sign to clockwise torques. A torque may be increased either by applying more force or by lengthening the distance between the axis and point of application.

The statics of fluids employs the same mathematical and physical principles as does solid statics. Typical problems in fluid statics include the determination of pressures, atmospheric forces, and forces on lighter-than-air craft.

stations of the cross The stations of the cross are a series of 14 representations that depict the events surrounding Christ's crucifixion. Used primarily by Roman Catholics as visual aids for meditating on the passion, they are mounted at intervals on church walls or placed in outdoor shrines. The idea of the stations emerged during the Middle Ages, when they developed as a devotional substitute for actually following the Via Dolorosa, the route in Jerusalem that Christ followed to Calvary. The events depicted are: (1) the condemnation of Jesus by Pilate; (2) Jesus' acceptance of the cross; (3) Jesus' first fall; (4) Jesus' encounter with his mother; (5) Simon of Cyrene helping Jesus; (6) Veronica wiping Jesus' face; (7) Jesus' second fall; (8) Jesus' encounter with the women of Jerusalem; (9) Jesus' third fall; (10) Jesus being stripped of his garments; (11) Jesus' crucifixion; (12) Jesus' death; (13) Jesus' removal from the cross; and (14) the burial of Jesus.

statistical thermodynamics see THERMODYNAMICS

statistics Statistics is the science of collecting and analyzing data. It is being used more and more in various applications. In government many people are involved in collecting data from censuses and surveys and monitoring trends in economic and financial indices. Such data are often referred to as "official statistics." They are used to evaluate and improve current policies. On a smaller scale, statistics is used in medicine, for example, to assess which of two treatments is better or to aid in the diagnosis of a patient.

There are many other examples. Statisticians are involved in agriculture, with the comparison of different fertilizers; in geology, with the estimation of oil resources; in the analysis of psychological experiments; in the actuarial profession, with the establishment of suitable premiums; in market research, to discover and interpret trends and frequencies; and in industry, in the optimization of production.

Although the science of statistics as a branch of applied mathematics has been developing since the beginning of the 20th century, its major impact has come in the past three decades or so, largely as a result of the revolutionary impact of electronic COMPUTERS, which make it possible to deal with large amounts of data rapidly and efficiently.

Chance and Probability. Statistical procedures can vary from the drawing and assessment of a few simple GRAPHS to carrying out very complex mathematical analysis with the use of powerful computers; in any application, however, there is the essential underlying influence of "chance." Whether some natural phenomenon is being observed or a scientific experiment is being carried out, the analysis will be statistical if it is impossible to predict the data exactly with certainty. Consider the tossing of a coin. The experiment is a random, or chance-influenced, phenomenon; the coin may land "heads" or "tails." Statistics can be more precisely defined as the collection and analysis of data from random experiments or phenomena (see RANDOM VARIABLE).

There is clearly an inevitable link between statistics and PROBABILITY, which provides the mathematical basis for setting up models to describe random phenomena. Many statistical techniques, particularly in the field of inference, are designed to use data to identify or assess the underlying probability model. The influence of probability is strong in physics and chemistry, where the term *statistics* is used in a slightly different sense. Statistical mechanics arose out of the kinetic theory of gases, in which the large-scale (macroscopic) properties of a gas are considered as the "averages" of the phenomena of microscopic collisions of many gas molecules moving in different directions and speeds. In genetics, Mendel's laws of heredity require for their statement the use of probability theory.

Statistical Procedures. Ideally, the statistician should be involved in any project from the start. First, the underlying population being investigated must be described, as implied in "the incomes of U.S. residents" or "all people suffering from hypertension." The statistician must make sure that the data are collected in a manner that allows them to answer the exact question posed. Sometimes it is not possible to sample this target population. Then the question must be changed slightly. It may involve setting up a SAMPLING procedure to select a small number of individuals from the population, as in opinion polls; or it may involve the allocation of different treatments to different patients. In the latter case, it is important that neither the patients nor the doctors know what the allocation is. Otherwise, their behavior or treatment might be systematically influenced. Usually the allocation will be achieved by a randomization procedure.

Once the data have been obtained, they must be examined, collated, and analyzed. In some cases, all that is needed is the publication of the numbers, as in the census results.

Before a specific analysis is made, important preliminary procedures such as tabulation, checking, summarization, and plotting of the data are needed. As an example, consider a study of the height of U.S. residents, using a representative sample of 2,000 heights as the data. One possibility is to write down all 2,000 observations; a more sensible approach, however, would be to count the data in various height groups and display the data as a HISTOGRAM. There are various ways in which the data might be summarized. An idea of the "central value" for the distribution can be conveyed by using the average value of the observations, the middle one (with the data written in increasing order), or the value where the histogram is tallest. These values from the data represent, respectively, the mean, the median, and the mode of the distribution. Another important feature of the distribution of the data is the variability or spread. A commonly used measure of this for a population is the variance, which is the average squared difference between the members of the population and the mean. From the data a sensible estimate of the variance can be computed. Its square root estimates the standard deviation, which is a useful measure of spread in the same units as the observations.

It is often useful to describe a probability distribution by a mathematical formula, which will contain a few unknown quantities called parameters; parametric statistical methods use the data to come to some judgment about these parameters. The commonest formula for data like height is that of the NORMAL DISTRIBUTION, which depends on two parameters, the mean (μ) and the variance (σ^2).

Hypothesis Testing and Estimation. For data from such a distribution, the statistical analysis concentrates on questions about the parameters. For example: (1) Is the mean height greater than 173 cm (68 in)? (2) Is the present variance in height greater than it was 50 years ago? (3) Is there a fairly reliable method of specifying an interval that contains the mean height? The first two questions involve the technique of hypothesis testing. The usual approach is first to set up a null hypothesis that the mean height is 173 cm (68 in) and then to assess the data on this basis. If the data suggest that the null hypothesis is implausible, then the hypothesis is rejected, and the answer to the question is taken as "yes." In the example, this would happen if the average height from the data is much greater than 173 cm (68 in). How much greater depends on the statistical significance that is required.

The other principal activity in inference is estimation. As has been suggested, the average of the datum values is a reasonable value of a point estimate of the mean in the population. It is therefore natural to construct interval estimates with this value as the center. One rationale is to have a method of constructing intervals that on average contain the true mean on a certain percentage of the occasions. These intervals are called confidence intervals, and the degree of confidence that is required will determine their width.

Procedures for hypothesis testing and estimation methods depend on the model. It is important to check the validity of the model, for example, the assumption that the height data satisfy a normal distribution. This can be done visually from the histogram or by using some other probability plot.

Sometimes the result of a statistical analysis has to be more definite, in the form of the selection of a policy—perhaps the choice of the best of several treatments for a disease. In such a case, the natural methodology to adopt is DECISION THEORY, in which the costs of wrong decisions are quantified and the effects of making different choices are compared.

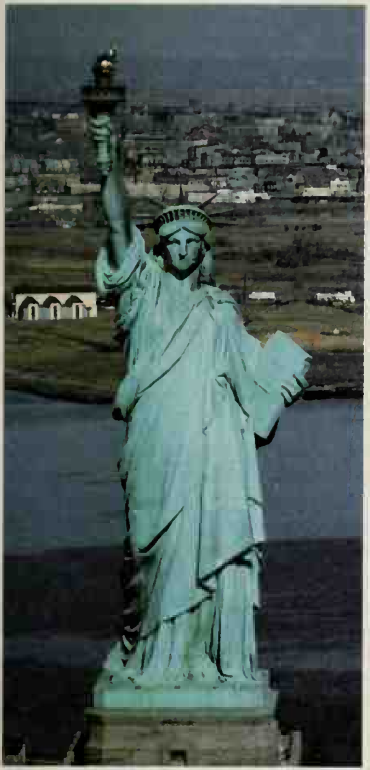
Data Relationships. There are many other specific types of data, with related models, problems, and techniques of analysis. Data may be qualitative, for example, the colors red, yellow, or blue; discrete, for example, numbers of cars; or continuous, for example, ages. Each observation may consist of a single value, as in the example about height, or many values, if several tests are carried out on each individual (multivariate analysis). Important questions may arise if there are two such tests. Suppose age and blood pressure are measured on a sample of patients. It is of interest to determine whether older people tend to have higher blood pressure. In statistical terms, the question is whether or not there is a positive correlation between age and blood pressure. (It should be emphasized that even if the answer, from a test of significance, turns out to be "yes," this does not prove any causal relationship between the two factors.) Some more specific relationship might be investigated, such as linear regression. This can be assessed graphically by plotting the points on a scatter diagram, a procedure that can be supported by calculations of the line of best fit, often by the LEAST-SQUARES METHOD. Examples of more complicated methods of analysis are time-series analysis—for example, the search for a trend, or regular fluctuation, in rainfall or economic indices—and factor analysis—the search for a few common factors governing the variation among many other variables.

There are many situations in which the measurements cannot be relied upon. For example, suppose that x and y are the examination scores of a student in chemistry and physics courses. One would expect them to be positively related. But one might not want to compute a correlation, because other teachers might grade the examinations differently. If, however, it were thought that different teachers would rank the students in the same order, a correlation of the ranks would be useful. Each individual would have a pair of ranks—his or her order in the group for chemistry and order in the group for physics. The rank correlation is frequently used in the social sciences.

The general idea of replacing observations by ranks leads to statistical methods that depend far less on assumptions, especially assumptions regarding the distribution of the data. This part of the subject is, therefore, called distribution-free statistics or, since distributions are often assumed to be described by formulas containing parameters, nonparametric statistics.

Statler, Ellsworth Milton [stat'-lur] Ellsworth Milton Statler, b. Somerset County, Pa., Oct. 26, 1863, d. Apr. 16, 1928, founded the chain of U.S. luxury hotels that bears his name. Statler's restaurant in Buffalo, N.Y. (1896), and a hotel that he built and operated there at the Pan-American Exposition of 1901 were his first enterprises. He was a prominent member of hotel trade groups. In 1954, Conrad Hilton bought the Statler chain of hotels.

Statue of Liberty The Statue of Liberty, 46 m (150.9 ft) high, was originally called *Liberty Enlightening the World*; it was conceived as a gift from the French to the American people to honor the 1876 centennial celebration. The exterior copper shell, in the form of a classical, draped female figure carrying a torch aloft, was designed (1870–75) by the French sculptor Frédéric Auguste BARTHOLDI; the wrought-iron pylon inside was the work of Gustave Eiffel, designer of the Eiffel Tower in Paris; and the stone-and-concrete pedestal was planned by the American architect Richard Morris HUNT. The statue was completed in Paris in 1884 and unveiled in New York Harbor on Oct. 26, 1886, in the presence of the sculptor. The funds for the statue were donated by the French people and those for the base by Americans.



The Statue of Liberty, located in New York Harbor, just southwest of Manhattan, was extensively restored and given a new torch with a gilded flame for its centennial rededication in 1986. President Reagan of the United States and President Mitterrand of France attended the Liberty Weekend 1986 rededication ceremony.

Probably the best-known symbolic image of America, the statue is also associated with the famous poem by Emma Lazarus inscribed at the base.

status Status refers to a person's position within an institutional or organizational framework. Thus, being middle class is a general status position within the system of social stratification. Status is the positional element in a structure or organization; role refers to the behavior associated with status. Both status and role can be reduced to the characterizations and behavioral expectations that constitute the foundation of all social life. Sociologist Talcott Parsons, for example, made what he called the "status role bundle" his basic analytical unit.

The most pointed and significant applications of status have been in the analysis of stratification, or systems of inequality. The distinctions developed by German sociologist Max Weber have been particularly influential. Weber made "status group" and "status situation" central categories in his political sociology. Whereas "class," following Karl Marx, refers to those aspects of life determined by one's economic situation (skills, wealth, knowledge, and so on), Weber's "status situation" means "every typical component of the life fate of men that is determined by a specific, positive or negative, social estimation of *honor*." Status situations may or may not be related closely to class. Status groups may include the propertied and unpropertied, or the moderately well-off and the rich, yet status groups tend toward exclusiveness through such mechanisms as preferred or enforced intragroup marriage and special systems of education. In Weber's scheme, castes and ethnic groups are major types of status groups.

Status systems are almost inconceivable without status symbols. Status symbols represent the group, in the sense of condensing the meanings central to the life of the group. Thus the six-inch-long fingernails of the Chinese mandarin symbolized his independence from any need to perform manual labor. Possession of virtually any kind of material object may become a symbol of one's status, a phenomenon systematically analyzed in the early 1900s by Thorstein Veblen, who coined the terms *conspicuous waste* and *conspicuous consumption*.

See also: CLASS, SOCIAL; NORM, SOCIAL; SOCIAL STRUCTURE AND ORGANIZATION.

statute of limitations The law specifying time limits during which legal action may be taken in certain cases is called the statute of limitations. In a civil case, it is a statute of repose, in that it sets a maximum period of time before the expiration of which a suit must be started. In a criminal case it is an act of grace; it specifies the length of time following commission of a crime after which the state may no longer prosecute. Further, the statute of limitations protects an individual from lawsuits in which evidence may not be obtainable due to the passage of time.

This statute figured in the historic Ex parte Milligan case. Following Milligan's release from prison on Apr. 10, 1866, he sued General Hovey, on Mar. 13, 1868, for unlawful imprisonment. A federal circuit court jury decided in favor of Milligan but awarded him only 5 dollars because the 2-year statute of limitations allowed him damages only for his incarceration from Mar. 13 to Apr. 10, 1866. The varying statute of limitations in different countries has been of some significance in recent years in the prosecution of war criminals.

Staubach, Roger [staw'-bak] Roger Thomas Staubach, b. Cincinnati, Ohio, Feb. 5, 1942, was an American professional football player who, as quarterback for the Dallas Cowboys of the National Football League (NFL), earned distinction for his passing and running skills and leadership qualities. He won (1963) the Heisman Trophy in his junior year at the United States Naval Academy, but his military obligation delayed his professional career until 1969. He led the NFL in passing in 1973, 1978, and 1979, and he piloted the Cowboys to 7 divisional, 5 league, and 2 Super Bowl championships. In 1979, Staubach had his best year, completing 267 out of 461 passes for 3,586 yd, with 27 touchdown passes. He retired in 1980 and was inducted into the Pro Football Hall of Fame in 1985.

Stavanger [stah-vahng'-ur] Stavanger is a port city in southwestern Norway on the Bokn Fjord, about 300 km

(185 mi) southwest of Oslo. The population is 97,716 (1990 est.). The city's harbor is ice-free year-round. Stavanger's industries include fish processing, shipbuilding, and the refining of North Sea petroleum. Points of interest include the Cathedral of Saint Swithin (begun 11th century), an archaeological museum, and an art gallery. Founded in the 8th century, Stavanger served as a bishopric from about 1125 to 1628 and again after 1924.

steady-state theory The steady-state theory is a cosmological theory proposed by Thomas Gold, Herman Bondi, and Fred Hoyle in 1948. It is based on the "perfect cosmological principle," namely, that the universe is homogeneous in space and time. According to its proposers, Hubble's constant does not change with time; the density of galaxies in the universe also remains unchanged. Instead, the expansion of the universe is ascribed to a repulsive force. New matter supposedly is being created continuously, forming new galaxies, so that the density of galaxies remains the same despite their mutual recession. Within an average volume equivalent to that within which a galaxy is found, according to the theory, a new galaxy is created once every 12 billion years. This corresponds roughly to a rate of creation of matter of one hydrogen atom per cubic kilometer per year. This rate of "continuous creation" is too small to be observed directly. The steady-state theory was an important milestone in the development of modern cosmology but has been discarded by most cosmologists because it cannot reasonably account for the 2.7 K microwave background radiation discovered by Arno A. Penzias and Robert W. Wilson in 1965. It is still supported by Hoyle and some others, however.

See also: BIG BANG THEORY; COSMOLOGY (astronomy).

Stealth bomber The U.S. Stealth bomber (officially, the B-2), developed under strict secrecy beginning in the 1970s, is a flying wing, or delta, whose shape, surface, and composition make it extremely difficult for radar systems to detect. Powered by four jet engines, Stealth has a range of more than 12,070 km (7,500 mi). The air force had planned to build a fleet of 132 B-2s by the 1990s, but the end of the cold war, as well as congressional questions about the craft's true performance and cost, have prevented full funding. The F-117A stealth fighter also uses stealth technology.

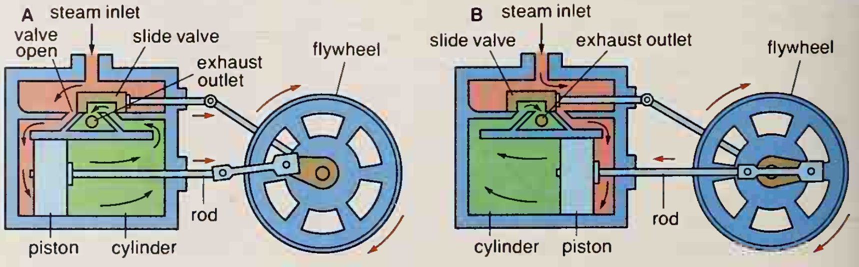
steam engine The steam engine was the first effective machine for producing power independently of human and animal muscle, wind, or flowing water. Its invention and application in the early 18th century was one of the foundations for the INDUSTRIAL REVOLUTION.

There are two fundamental forms of steam engine, reciprocating and turbine. The latter, used for modern electrical generation, is generally called a steam TURBINE. The reciprocating engine is the classic form, whose elaboration and refinement was one of the great triumphs of 18th- and 19th-century technology.

The beginnings of steam technology are usually traced to a 1698 invention of Thomas Savery, in Devon, England. His "Miner's Friend" used high-pressure steam to evacuate a metal chamber; when the steam was condensed by injecting cold water into the chamber, the resulting vacuum drew water upward from a flooded mine. The cycle then recommenced by forcing that water out with more steam.

The first true "engine" using steam was invented about 1712 by another Englishman, Thomas NEWCOMEN. His "atmospheric engine" operated on low-pressure steam, which was used to displace the air from a cylinder. Again, water was injected to condense the steam, but this time the vacuum caused a piston to move downward. When the piston was attached to a pivoted beam, this action could be used to lift a pump rod on the other end. The Newcomen engine acted only in one direction, pulling the piston down; it was raised by counterweights on the pump rod. By the mid-18th century this rather inefficient engine was widely used for pumping water but had no other application.

The broader application of steam power began with several key improvements by the Scot James WATT, in the 1760s and '70s. His "separate condenser" increased the efficiency of the Newcomen engine by allowing the main engine cylinder to be kept hot, shunting the cooler, condensing steam to a small, separate chamber that could be kept cold. Watt then devised the first "double-acting" engine, in which the steam was introduced alternately to both sides of the piston, thus powering the upstroke as well as the down. This made it possible to attach the piston rod to a crank or set of gears to produce rotary motion, as in driving the wheels of a carriage or the paddles of a riverboat. By the late 18th century the steam engines produced by Watt and his partner, Matthew BOULTON, were



In a double-acting steam engine, steam drives the piston from both sides of the cylinder. (A) As the slide valve moves, steam enters the left side of the piston cylinder while spent steam leaves through the exhaust outlet. (B) Steam pressure pushes the piston to the right; the slide valve moves to close the left valve opening and open the right. The flywheel carries the piston over the dead periods at the end of each stroke.

powering factories, mills, and pumps in Europe and America.

Early in the 19th century the Boulton-Watt low-pressure engine—which was relatively efficient but was also quite heavy—was joined by an important alternative, the high-pressure steam engine pioneered by Richard Trevithick in Britain and Oliver Evans in the United States. This design, which could be made in relatively small versions, became the basis for the 19th-century revolution in transportation when applied to railroad locomotives and river- and oceangoing vessels. In its simplest form the high-pressure engine depended greatly upon the fact that when water is converted to steam it expands to occupy a volume as much as 1,600 times the original. In a confined space, such as an engine cylinder, this expansion manifests itself as pressure and forces a piston back and forth in a cylinder, entering alternate sides of the piston by means of self-acting valves. All work is done through steam pressure, rather than by condensation. Trevithick showed in 1804 that the high-pressure engine could be made to operate a locomotive, although it was another quarter-century before locomotives began to be used widely.

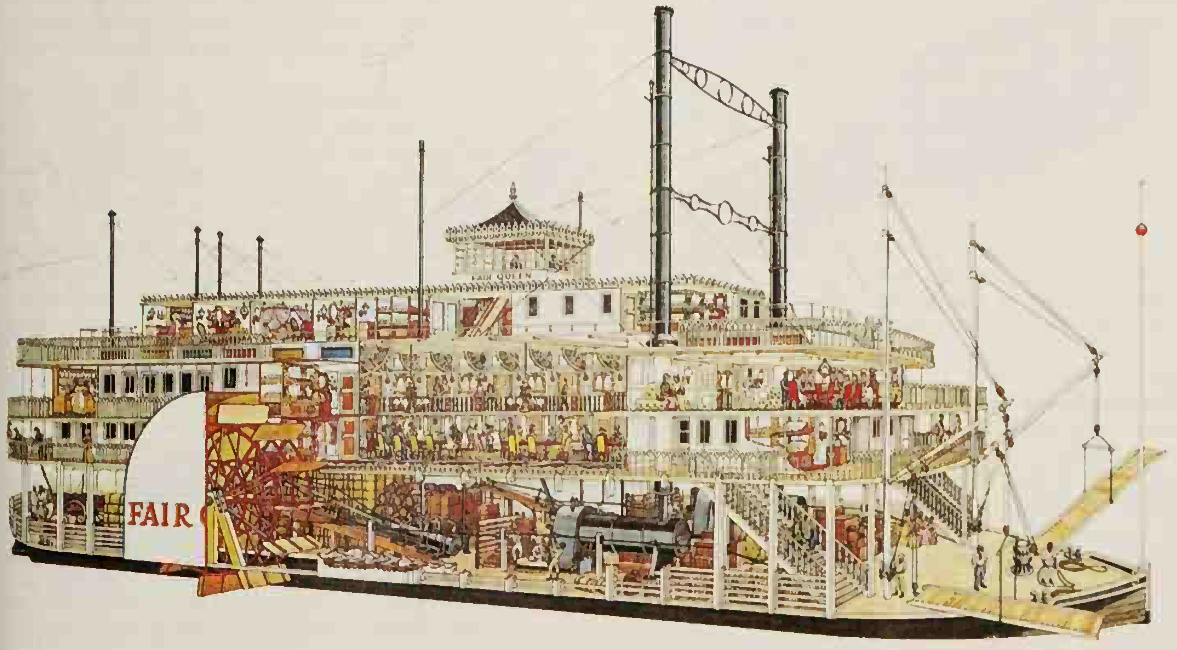
The steam engine became the most important prime mover of the 19th century. The low-pressure, condensing form was used in factories, waterworks, mines, and wherever a large, centrally located power source could be useful. The high-pressure version found its most important application in transportation but was also used in shops and other places where a small, easily operated and maintained engine was needed. Many variations on both condensing and high-pressure engines were developed in the continuing effort to improve fuel efficiency, reliability, and power-to-weight ratios. These variations included hybrid forms, such as compound and multiple-expansion engines.

Today reciprocating steam engines are rare, having been displaced by steam turbines for large applications such as electrical generation, by internal-combustion engines for transportation and portable power sources, and by electric motors for shop and domestic use.

steamboat The term *steamboat* usually refers to a small, shallow-draft vessel operating on inland waters, as distinguished from the large seagoing steamship. As early as 1685, French physicist Denis Papin proposed that steam could be used to propel a ship by means of a paddle wheel. James Watt's improvement of the steam engine in 1769 was followed by the first steamboat, navigated on the Saône River in France in 1783 by Claude Jouffroy d'Abbans.

The first steamboat to find practical application was a paddle-propelled vessel demonstrated in 1787 on the Delaware River at Philadelphia by John Fitch. In 1790, Fitch established the world's first steamboat passenger

The Mississippi riverboat, which developed from simpler steamships of the early 1800s, became the Mississippi's dominant form of passenger and commercial transport by the mid-19th century. Designed to hazard sandbars and shallows, the flat-bottomed, shallow-hulled craft supported a light but lofty wooden superstructure. Its steam engines burned either coal or wood, powering two large, lateral flywheels. The elegant passenger quarters of the upper decks were crowned by a small pilothouse, from which the captain could survey the river.



service, between Philadelphia and Trenton; it was a technical success but a commercial failure.

European experiments continued—notably William Symington's *Charlotte Dundas*, built in 1801 to tow boats on the Forth and Clyde Canal in Scotland and equipped with a crankshaft connection between piston and paddle wheel. The immensely greater need for steam navigation in America, however, inspired the major developments. In 1802, John Stevens (see STEVENS family) of New York built the *Polacca*, the first steamboat with a screw propeller. Robert FULTON navigated an experimental steamboat on the Seine in Paris in 1803. In 1807, Fulton built the *North River Steamboat* (later renamed the CLERMONT), a long, low, flat-bottomed, box-shaped vessel powered by an imported Watt engine. Although its only innovative feature was the shape of its hull, the vessel's extraordinary commercial success was a historic turning point.

In 1815 the *Enterprise*, with a high-pressure engine of the type invented by Oliver EVANS, inaugurated a profitable commercial service on the Mississippi River. By 1830 nearly 200 steamboats operated on the Mississippi, and the river steamboat had developed its characteristic configuration: a straight-sided, flat-bottomed, and shallow draft. The intense speed rivalry of Mississippi boats was memorialized in the famous race between the *Robert E. Lee* and the *Natchez* in 1870. The boats went from New Orleans to St. Louis in less than 4 days; the *Robert E. Lee* won.

steatite see TALC

steel see IRON AND STEEL INDUSTRY

steel band First developed in Trinidad in the 20th century, the steel band is made up of percussionists whose instruments are fashioned mainly from oil drums and are termed *pans*. The process for creating a pan includes beating the top of the drum into a concave shape (sinking), marking the pan into sections and hammering each one to correspond to a certain pitch (grooving), cutting the top from the drum at a depth that will define its overall pitch, heating the pan for tone, and fine-tuning with a small hammer. Pans are played with pairs of rubber-tipped sticks. The three basic types of pan are tenor pans that play melody, rhythm pans that play harmony, and bass pans. The steel band, which can contain numerous performers, is used extensively in the playing of CALYPSO music.

Steel, David Martin Scott A member of Parliament from Scotland since 1965, David Martin Scott Steel, b. Mar. 31, 1938, was leader of the British Liberal party from 1976 to 1988. Educated in Nairobi, Kenya, and at Edinburgh University, Steel had begun his career as the youngest member of Parliament. He was instrumental in creating the Liberal–Social Democratic party alliance of 1981, and the merger between the two parties to form the Social and Liberal Democrats in 1988. Steel was knighted in 1990.

Steele, Sir Richard An essayist, dramatist, and political writer of the English AUGUSTAN AGE, Sir Richard Steele, b. Dublin, Mar. 12, 1672, d. Sept. 1, 1729, is remembered mainly for his collaboration with Joseph ADDISON in the two great series of periodical essays, the *Tatler* (1709–11) and the *Spectator* (1711–12).

Having left Oxford for the army in 1692, Steele launched his writing career with publication of his first poem, "The Procession," in 1695. He later turned to stage comedy, producing *The Funeral* (1701), *The Lying Lover* (1703), and *The Tender Husband* (1705). After serving (1713–22) as a Whig member of Parliament and holding minor government posts, he reverted to the stage with *The Conscious Lovers* (1722). The success of this play began a vogue of "weeping" comedies in which a virtuous hero and heroine come to happiness through adversity. This work, however, was Steele's last; in 1726 he suffered a crippling stroke.

Steele was a zealous crusader for morality and published a manual of religious devotion, *The Christian Hero* (1701). The *Tatler*, written mainly by Steele under the pseudonym of Isaac Bickerstaff, employed the popular periodical essay form to accomplish a new purpose: to refine the manners of its readers. The essays are discussions of current events, literature, and gossip in a deftly ironic style that teases readers into laughing at themselves. The style and purpose of the *Tatler* were continued in the *Spectator*, the writing of which was shared about equally by Addison and Steele.

Steen, Jan [stayn] The works of the Dutch painter Jan Steen, *c.*1626–1679, represent the climax of the Haarlem school of genre painting. His prodigious output of paintings reflects a familiarity with the clear lighting and hermetic interior scenes of Jan Vermeer and Pieter de Hooch.

As a Roman Catholic in a country dominated by Protestants, Steen executed his many religious paintings with an urgency uncommon in 17th-century Dutch art. He is best known, however, for his genre scenes depicting lower-class life in taverns and brothels. As the owner of a tavern, he had firsthand knowledge of such places and presented their bawdy drunkenness and vulgarity, as well as their occasional cruelty, without sentimentality and with a saving sense of humor. An exceptional draftsman and a keen observer, he was adept at compressing entire narratives into a single scene populated with vividly rendered characters, as in his *Feast of Saint Nicholas* (*c.*1660–65; Rijksmuseum, Amsterdam).

steeplechase A steeplechase is a race for people or horses, over a prescribed course that includes such obstacles as timber rails, stone walls, brush fences, and water hazards. The race takes its name from the early contests in which a local church with a tall steeple was used as a landmark. Steeplechase races using horses can be traced back to 18th-century fox hunting in England and Ireland.

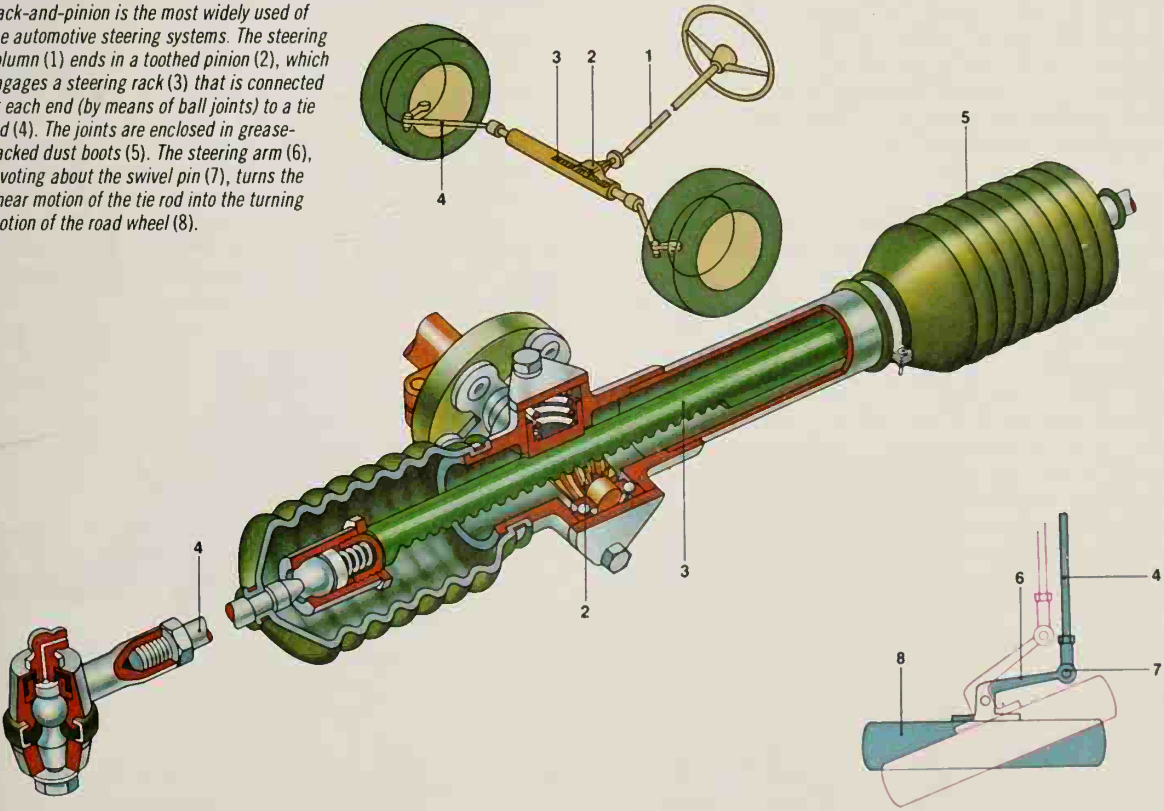
The Grand National, England's most prestigious steeplechase, covers a course of approximately 7,220 m (7,896 yd) that includes 30 obstacles. One of the oldest horse races in the world, the event has been held annually at Aintree, England, since 1839.

The first organized steeplechase, the Grand National, was held at Aintree, England, in 1839. This race is still considered the most prestigious in the world. Steeplechase racing was first introduced into the United States from Canada in 1865 at Paterson, N.J. Steeplechasing is a favorite sport for amateur riders, and events are usually organized by local hunt clubs.

The track and field steeplechase event challenges the skills required for middle-distance running, for hurdling, and for overall balance. At present, the standard steeplechase is run over a 3,000-m (3,281-yd) course, with 35 obstacles. Hurdles are 3 ft (.91 m) high; water obstacles occur after every fifth hurdle and are 12 ft (3.7 m) wide. The first steeplechase was run in 1850 in Oxford, England, and has been an Olympic Games event since 1900.

steering system An automobile steering system allows the driver to control the vehicle's direction. Rotation of the steering wheel is translated, through gearing and a network of rods and joints (the steering linkage), into right or left movement of the car's front wheels.

There are two basic types of steering systems: rack-and-pinion, and worm-and-roller (or worm-and-key). The rack-and-pinion is the simplest, and the one most commonly used in modern cars. In rack-and-pinion linkage, the steering shaft, connected at one end to the steering wheel, has a pinion gear at its opposite end. The gear meshes with threads in a steering rack, which is mounted across the car and is connected by tie rods to the front wheels. The steering wheel turns the steering shaft; the pinion gear on the shaft's end moves the steering rack to the right or left and thus moves the wheels. Rack-and-



Rack-and-pinion is the most widely used of the automotive steering systems. The steering column (1) ends in a toothed pinion (2), which engages a steering rack (3) that is connected at each end (by means of ball joints) to a tie rod (4). The joints are enclosed in grease-packed dust boots (5). The steering arm (6), pivoting about the swivel pin (7), turns the linear motion of the tie rod into the turning motion of the road wheel (8).

pinion systems use few moving parts but perform precisely and efficiently.

In worm-and-roller systems the steering shaft ends in a gearbox, which is connected to the steering linkage by a special rod called a Pitman arm. On the left side of the car, an idler arm is mounted parallel to the right-mounted Pitman arm. The arms are connected by a relay rod. Inserted into the relay rod are tie rods connecting it to the two front wheels, and short tire-steering arms that are joined to the tie rods by ball joints. Inside the gearbox the worm—a spiral-threaded gear on the end of the steering shaft—meshes at right angles with a roller, or a key. (A roller is a threaded gear; a key is a device with a single tooth that engages the threads of the worm gear.) As the steering wheel is turned, the roller or key moves right or left along the worm gear, swiveling the Pitman arm.

The recirculating-ball steering gear resembles the worm-and-roller mechanism, except that the gears ride on a number of ball bearings, which act as lubricants, reducing gear friction.

Many modern vehicles have power-assisted steering, which uses hydraulic pressure to reduce the effort needed to steer. In the most common system, a power steering pump, connected by a belt to the engine, sends high-pressure fluid to the steering gearbox, where it aids in moving the gears.

Innovative 4-wheel steering (4WS) is now available in two modes: either all 4 wheels turn in the same direction, or front and rear wheels turn in opposite directions. Both systems are said to produce the same effects: parking is far easier, and high-speed maneuvers are safer because "fishtailing" is reduced. In either mode, 4WS is still relatively untried, but it may prove eventually to be the steering system of the future.

Steffens, Lincoln [stef'-uhnz] One of the most eminent American reformers and journalists around the turn of the 20th century, Joseph Lincoln Steffens, b. San Francisco, Apr. 6, 1866, d. Aug. 9, 1936, was a leader of the MUCKRAKERS. As managing editor (1901–06) of *McClure's Magazine*, he wrote a series of articles that documented graft and corruption in American cities, asserting that some cities were run by political bosses who remained in power with the help of powerful businesspeople. These articles appeared in book form as *The Shame of the Cities* (1904), *The Struggle for Self-Government* (1906), and *Upbuilders* (1909).

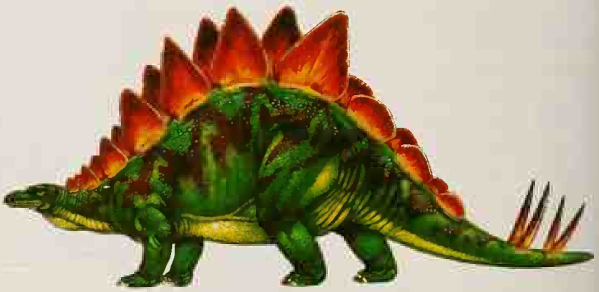
Steffens joined with other muckrakers in the development (1906) of *American Magazine* and later continued to question existing social processes. After visiting the USSR and meeting Lenin in 1919, he wrote: "I have seen the future and it works." Steffens's *Autobiography* was published in 1931.

Stegner, Wallace [steg'-nur] Wallace Stegner, b. Lake Mills, Iowa, Feb. 18, 1909, is a prolific writer whose novels center about life in the American West. Best known is *The Big Rock Candy Mountain* (1943), a sprawling work describing a Norwegian family's struggle to establish a home in the West during the early 1900s. Other major titles by Stegner include *The Preacher and the Slave* (1950), a fictionalized account of labor leader Joe Hill; *Angle of Repose* (1971), a reconstruction of the life of Western novelist Mary Hallock Foote, for which Stegner won the Pulitzer Prize; the 1977 National Book Award winner *The Spectator Bird* (1976); and the semiautobiographical novel *Crossing to Safety* (1987).

Stegosaurus [steg'-uh-sohr-uhs] *Stegosaurus* is one of the plated DINOSAURS, suborder Stegosauria, order Ornithischia; it grew to about 6 m (20 ft) long, 2.5 m (8 ft) high at the hips, and about 4 tons in weight. Its fossil remains have been found in western North America in late Jurassic rocks about 150 million years old. Related forms have been found in Europe and Africa, but stegosaurs apparently were never very abundant or diverse.

Stegosaurus had a blimplike body, long hind legs, short front legs, a short, stocky neck, and a small head. Its long, heavy tail carried several pairs of long, bony spikes, presumably used as defensive weapons. The midline of the back bore alternating, triangular, bony plates that were probably attached by ligaments to the spine and could stand upright. The small head and the mouth, with up to about 25 tiny teeth on each side of the upper and lower jaws, seem ill-designed to have fed such a ponderous body. *Stegosaurus* is famed for having a brain no larger than a walnut.

The bony plates on the back have been interpreted by some paleontologists as defensive armor against predators. Studies indicating that the plates may have carried an extensive network of blood vessels have also led to the hypothesis that they were used for absorbing solar heat to control body temperature—a matter involving the debate over whether dinosaurs were hot- or cold-blooded. Recent studies indicate that stegosaurs carried a single row of about 17 alternating plates rather than the double row usually depicted in reconstructions.



The Stegosaurus *was a dinosaur that became extinct about 140 million years ago. It had a plated, corpulent body, a walnut-sized brain, and long spikes on its tail, which it used for defense.*

Steichen, Edward [sty'-ken] A major force among 20th-century photographers, Edward Steichen, b. Luxem-

Edward Steichen's The Flatiron Building—Evening, *photographed in New York City in 1905, is a classic study of shadow and atmosphere. Steichen experimented constantly with new techniques.*

bourg, Mar. 27, 1879, d. Mar. 25, 1973, was a leader in the movement to gain acceptance of photography as a fine art. Together with Alfred STIEGLITZ, Clarence H. White, and others, he helped found (1902) the Photo-Secession group in New York; thereafter he served as Stieglitz's lieutenant on the journal *Camera Work* (1903–17) and in mounting exhibitions of the work both of Photo-Secession members and of major French artists not yet known in America.

Until 1914, Steichen specialized in soft-focused photographic images evocative of the paintings of the postimpressionists and symbolists. During World War I he contributed to the development of aerial photography, an experience that led him after 1919 to a different photographic approach, characterized by clearer, more sharply focused images, and experiments with a variety of light settings, as in his close-up studies of plant life and natural, abstract forms. From 1923 to 1938, Steichen practiced commercial photography in New York, where he was chief photographer for *Vogue* and *Vanity Fair* magazines. In charge of the U.S. Navy's combat photography unit during World War II, Steichen later directed (1947–62) the Museum of Modern Art's photography department, under whose auspices he organized (1955) the celebrated Family of Man exhibition that later toured 37 countries. Steichen's last notable work was the experimental color filming (1965) of the seasonal moods of a shadblow tree located on his Connecticut estate.

Steiger, Rod [sty'-gur] A graduate of the Actors Studio, Rod Steiger, b. Westhampton, N.Y., Apr. 14, 1925, has had a distinguished career as a leading character actor in films since 1951. His most notable roles have been in *On the Waterfront* (1954), *The Pawnbroker* (1964), *In the Heat of the Night* (1967), for which he won an Academy Award, *The Sergeant* (1968), as Napoleon in *Waterloo* (1970), and as W. C. Fields in *W. C. Fields and Me* (1976).

Stein, Gertrude Best known for her innovative prose style, Gertrude Stein, b. Allegheny, Pa., Feb. 3, 1874, d. July 27, 1946, exercised a major influence on American writers of the post–World War I generation, which she was the first to describe as "lost." Raised in California, she graduated from Radcliffe College in 1897, then attended Johns Hopkins Medical School for four years without taking a degree. Stein settled in Paris in 1903, first sharing an apartment with her brother Leo and thereafter with her lifelong companion, Alice Toklas.

Stein's first book, *Quod Erat Demonstrandum*, written in 1903 and published in 1950 under the title *Things as They Are*, was a conventional novel influenced by Henry James. The direction of her work changed in *Three Lives* (1905–06; publ. 1909), where, in the central story, "Melanctha," Stein began to develop her characteristically abstract style. In her massive *The Making of Americans* (1906–08; publ. 1925), an attempt to render the essence of characters and their interrelationships led her to jettison traditional narrative structure in favor of slow-moving, repetitive images of the continuously evolving present. From then on, the relation between Stein's work and painting became quite explicit. Her notoriously difficult work, *Tender Buttons* (1941), were poems that formed a series of "cubist" still lifes.

Stein did not achieve genuine fame until the mid-1920s, when her literary friendships with Sherwood Anderson and Ernest Hemingway carried her name and works widely into print. In the 1920s, Stein also wrote literary criticism and drama in such works as *Composition as Explanation* (1926) and the opera *Four Saints in Three Acts* (publ. 1929, produced 1934), on which she collaborated with the composer Virgil Thomson. Not until 1933

Gertrude Stein, an American writer, is seen in a portrait (c. 1906) by Pablo Picasso, one of many artists she influenced. The expatriate writers Stein called the "lost generation" met in her Paris salon. (Metropolitan Museum of Art, New York City.)

did she publish her best-selling *Autobiography of Alice B. Toklas.*

The following year Stein toured the United States, returning for the first time in 30 years. Her talks before audiences became *Lectures in America* (1935). A few years later she wrote an account of that tour in *Everybody's Autobiography* (1937). In her last decade Stein wrote in many genres: literary criticism in *The Geographical History of America* (1936); art criticism in *Picasso* (1938); a memoir, *Wars I Have Seen* (1945); drama in the opera *The Mother of Us All* (1947); and the novel *Mrs. Reynolds* (1952). She died in Paris.

Stein, Heinrich Friedrich Karl, Freiherr vom und zum [shtyn] Heinrich Friedrich Karl, Freiherr vom und zum Stein, b. Oct. 26, 1757, d. June 29, 1831, chief minister (1807–08) of Prussia, was the driving force behind the Prussian reform movement after the near annihilation of the state by Napoleon I in 1806–07. He came from a family of imperial knights who owed allegiance only to the Holy Roman emperor. In 1780, Stein entered the Prussian service, and by 1804 he had risen to the top levels of government.

Stein's zeal for reform was fired by the military defeat of Prussia at the hands of Napoleon and the absorption of his own estates into the duchy of Nassau. Stein was appointed chief minister, and in only 14 months as head of the government, he created a council of responsible ministers shielded from royal caprice, abolished serfdom, removed restrictions on property ownership and choice of occupation, introduced home rule for the cities, and promoted Gen. Gerhard von SCHARNHORST's military reforms.

Dismissed under pressure from Napoleon in November 1808, Stein fled to Austria and then to Russia. During the War of Liberation (1813–14), he fomented popular resistance to the rule of Napoleon's German clients and directed the allied occupation of conquered German territories. As advisor to Russian emperor Alexander I at the Congress of Vienna (see VIENNA, CONGRESS OF), he labored in vain for the restoration of the imperial knights and a unitary empire. Embittered at failure, he retired to his estates to study history.

Steinbeck, John [styn'-bek] An American author and winner of the 1962 Nobel Prize for literature, John Ernst Steinbeck, Jr., b. Salinas, Calif., Feb. 27, 1902, d. Dec. 20, 1968, based most of his novels on the American experience, often with sympathetic focus on the poor, the eccentric, or the dispossessed.

Steinbeck's first published book, *Cup of Gold* (1929), was not successful. He then turned to the valleys of rural California for his settings and characters. *The Pastures of Heaven* (1932) contains a series of closely linked tales about residents of California. *To a God Unknown* (1933) relates a mystical story of self-sacrifice and is one of Steinbeck's strongest statements about the relationship between people and the land. *The Long Valley* (1938) is a collection of short stories, among them "The Red Pony," which chronicles the initiation of a ranch boy, Jody Tiflin, into manhood.

John Steinbeck received the Nobel Prize for literature in 1962 for his contribution to American letters. Before achieving literary success during the mid-1930s, Steinbeck worked as a laborer. The Grapes of Wrath *(1939) and other novels portray the social injustice faced by the poor and dispossessed.*

Photo Philippe Halsman © 1972

Steinbeck's first popular success was *Tortilla Flat* (1935; film, 1942), an episodic tale that recounts semihumorously the adventures of a raffish band of Mexican Americans. The books that ensued were grim. *In Dubious Battle* (1936) is the tragic story of a young labor organizer during an apple pickers' strike. *Of Mice and Men* (1937) depicts the lives of two itinerant farm workers and the tragedy that comes when their dreams are shattered. Written as a "play-novel," it was produced on Broadway in 1937 and filmed in 1939. *Their Blood Is Strong* (1938) is a nonfictional account of conditions in migrant agricultural workers' camps derived largely from articles written for the *San Francisco News.* It probably formed the basis for The GRAPES OF WRATH (1939; film, 1940), which won the 1940 Pulitzer Prize for fiction and brought attention to the plight of dispossessed farmers.

After World War II, Steinbeck wrote increasingly about social outcasts. *Cannery Row* (1945; film, 1982) relates the story of a central character, Doc, and a group of vagabonds on the Monterey coast. *The Pearl* (1947; film, 1948) is a popular fable about a Mexican fisherman who finds and finally discards a valuable pearl that brings him only grief. *The Wayward Bus* (1947; film, 1957) presents a morality tale about characters who supposedly represent middle-class society. *Burning Bright* (1950), a play-novel, preached universal brotherhood. Steinbeck devoted several years to his most ambitious project, *East of Eden* (1952; film, 1955), which paralleled the history of his mother's family and was an allegorical modernization of the biblical story of Adam.

Steinbeck spent many of his later years writing a modern version of Malory's *Morte d'Arthur,* published posthumously and incomplete as *The Acts of King Arthur and His Noble Knights* (1976). He also wrote about his travels and opinions in *Once There Was a War* (1958), *Travels with Charley* (1962), and *America and Americans* (1966).

Steinberg, Saul [styn'-burg] The work of the noted cartoonist Saul Steinberg, b. Romania, June 15, 1914, has appeared in many magazines, including the *New Yorker*, since 1941. His style is wholly individual, revealing humor, satire, fantasy, and philosophy through a rich visual vocabulary of rubber stamps, official seals, thumbprints, silhouetted figures, and illegible script. Many of his cartoons deal with problems of identity, disguise, and metamorphosis, but precise meanings remain obscure. Although Steinberg's work spans more than 40 years, there have been relatively few stylistic changes.

Steinberg, William William Steinberg, b. Cologne, Germany, Aug. 1, 1899, d. May 16, 1978, was a conductor who stressed precision and nonromantic, objective musical interpretations. After serving as an assistant to Otto Klemperer, he conducted opera in Cologne (1924), Prague (1925–28), and Frankfurt (1929–33). Forced out of this last position by the Nazis, he conducted (1933–36) concerts for the Jewish Cultural League and then fled to Palestine. In 1938 he moved to New York to become Arturo Toscanini's assistant with the NBC Symphony, and in 1945 he took over the Buffalo Philharmonic. From 1952 to 1976 he directed the Pittsburgh Symphony.

Steinem, Gloria [styn'-uhm] An American journalist and political activist, Gloria Steinem, b. Toledo, Ohio, Mar. 25, 1934, is best known as an editor of *Ms.*, which she helped to found in 1972, and as a dedicated proponent of women's rights. She has campaigned vigorously for liberal Democratic party candidates, the United Farm Workers, black civil rights, the antiwar movement, and the Equal Rights Amendment. A cofounder of *New York Magazine* in 1968, Steinem joined the women's movement later that year and in 1971 helped organize the National Women's Political Caucus. Among other endeavors is her 1986 biography of Marilyn Monroe; she also was a contributing correspondent (1987–88) on television's "Today" show.

Steiner, Rudolf [shtyn'-ur] The Austrian philosopher, scientist, and artist Rudolf Steiner, b. Feb. 27, 1861, d. Mar. 30, 1925, was the originator of the social philosophy called anthroposophy. A Christianized version of THEOSOPHY, this doctrine asserts that humans possess a faculty of spiritual cognition, or pure thought, which functions independently of the senses. Anthroposophy strives for the most effective development of this faculty. Steiner founded the Anthroposophical Society in 1912. His teachings were instrumental in the development of the Waldorf School movement and of schools for handicapped or maladjusted children.

Steinkraus, Bill [styn'-krows] William Clark Steinkraus, b. Cleveland, Ohio, Oct. 12, 1925, an American equestrian, began his career in horsemanship at the age of 10 and by 1940 had already won national titles. At the 1952 Olympic Games he was a member of the U.S. jumping team that won a bronze medal; in 1960 and 1972, Steinkraus helped win the Olympic silver medal in team competition. Riding the 10-year-old gelding Snowbound in the 1968 Olympics, Steinkraus became the first American to win an individual gold medal in the jumping competition.

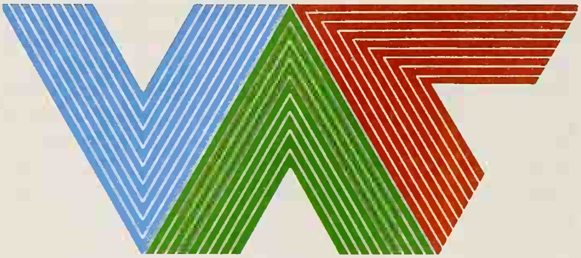
Steinmetz, Charles Proteus [styn'-mets] Charles Proteus Steinmetz, b. Karl August Rudolf Steinmetz in Breslau, Germany, Apr. 9, 1865, d. Oct. 26, 1923, was a German-American electrical engineer who made important contributions to the understanding of basic electrical phenomena.

Steinmetz immigrated to the United States in 1889 and immediately found employment as an electrical draftsman and electrical engineer in the Yonkers, N.Y., shop of Rudolf Eickemeyer. In addition to learning English, applying for citizenship, and joining professional societies, he carried out his first important research, discovering the law of hysteresis, which made it possible to calculate the loss of electric power due to magnetism. This discovery, in turn, made possible the design and construction of more efficient transformers, generators, and motors. In 1893 he joined the General Electric Company in Schenectady, N.Y., and was soon made consulting engineer, a position he held until his death.

Steinmetz had begun studies on alternating current (AC) in the 1890s when it was a little understood and complex subject. He continued his research at General Electric, patenting more than 100 inventions. Over the course of nearly 25 years he developed and refined a mathematical method for making AC calculations; he published and explained his method in a series of papers, articles, and textbooks.

stele [stee'-lee] A stele is an upright stone slab or shaft that, in ancient times, served as a monument, memorial, or marker and was generally inscribed. In ancient Egypt and Greece the most common type was the funerary stele, sometimes rectangular or square in shape but more often with a rounded top, like the modern TOMBSTONE, which is a direct descendant of the Egyptian type. Such stelae were inscribed with the name and often the titles of the deceased as well as a funerary prayer. Commemorative stelae were sometimes erected by rulers to record their deeds in war or benefactions to a temple. Elsewhere in the ancient world stelae were erected by the Chinese and by the MAYA of pre-Columbian Mexico and Central America. Ancient Maya stelae generally were placed before temples and carved with rulers' portraits and texts recording political and military exploits.

Stella, Frank A member of the New York school of abstractionists, the painter Frank Stella, b. Malden,



Quathlamba *(1964) is a canvas painted by the American abstract artist Frank Stella. The work demonstrates Stella's formal concerns with polychromy, marked shaping, and industrial precision. (Private collection.)*

Mass., May 12, 1936, attracted much critical attention during the 1960s and '70s, especially for the striped, repetitious "black paintings" (1960s) that were seen as a formalist attack on abstract expressionism. He advanced from his minimal black canvases to richer, more colorful, metallically striped works and the Day-Glo geometric figures in the "Protractor" series. During the 1970s he moved from stripes to angular overlays of planes, going so far as to construct his paintings of cardboard, wallboard, or metal—similar patterns were repeated in a series of each—with adjoining planes of color tilted slightly away from the picture plane. He has also explored the use of color in curved designs.

Stella, Joseph In his views of New York City, the painter Joseph Stella, b. Naples, May 13, 1877, d. Nov. 5, 1946, dramatically reorganized its modern structures into transparent cubist-futurist planes and crystalline forms. His first important picture was *Battle of Lights, Coney Island* (1913–14; Yale University Art Gallery, New Haven, Conn.), a dynamic, explosive work. His best-known canvas, *Brooklyn Bridge* (1919–20; Yale University Art Gallery), was followed by other versions of the same subject and by a five-part series called *New York Interpreted* (1920–22; Newark Museum, N.J.). Stella's later paintings are eerie tropical landscapes filled with anthropomorphic shapes.

stellar evolution Stellar evolution is the series of phases that a STAR passes through between its birth and its death. Because stars are large, hot masses of gas that emit huge amounts of energy into space and because stars have only a limited energy supply available, they must eventually exhaust their supply and burn out. Likewise, they must have originated at some time in the past.

Formation. The space between the stars contains gas and dust at a very low density. This INTERSTELLAR MATTER tends to gather into clouds, known as NEBULAE. Sometimes the density of a nebula becomes high enough so that its gravity is sufficient to cause contraction, leading to the formation of a star or a group of stars. A ball of the gas that is shrinking in size and will soon become a star is known as a protostar. Such protostars are believed to have been observed in some of the large interstellar clouds of the Milky Way. As a protostar slowly contracts its pressure and temperature increase. The temperature rise is due to the release of gravitational energy as the protostar gets smaller in size. Any hot object radiates energy, and the protostar eventually becomes hot enough to shine.

The temperature at the center of the protostar will finally become high enough to initiate nuclear reactions and the subsequent release of nuclear energy. Hydrogen is the most abundant element, and hydrogen-burning reactions, in which hydrogen is converted to helium with an accompanying release of large amounts of energy, are the first ones to become important.

When the nuclear energy released exactly balances the radiation energy lost into space, the protostar enters a state of energy balance. At this point of energy balance and pressure-gravity balance, the object becomes a true star.

Hydrogen-Burning. A star that is in balance and that is burning hydrogen in its core is called a main sequence star. On a plot of luminosity versus temperature, known as a HERTZSPRUNG-RUSSELL DIAGRAM, main-sequence stars fall into a diagonal line. All stars begin their careers in the main-sequence phase. If a main-sequence star has a large mass, it will have a high surface temperature and will therefore be very luminous. If it has a small mass, it will be rather cool and faint. The Sun is a main-sequence star somewhat above average in mass, surface temperature, and radiant energy output.

When the hydrogen fuel in the core is used up, the star loses its main-sequence status. This can happen in less than a million years for the most luminous stars, while it will take many trillions of years for the faintest. The Sun has a main-sequence lifetime of about 10 billion years, half of which is still in the future.

Helium-Burning. When the core hydrogen has all been converted to helium through nuclear reactions, the nuclear energy release will stop. The star will fall out of energy balance, and the central portions will contract further under gravity and get still hotter. The end of nuclear reactions does not, however, stop a star from radiating energy into space; stars shine because they are hot, and the post-main-sequence star is still quite hot.

As the central parts of a star get hotter, nuclear reactions can be resumed. This can be in the form of hydrogen-burning in the regions just outside the helium core, and it can also be in the form of helium-burning reactions in the core itself. Any nucleus can undergo nuclear reactions if conditions are violent enough. More nuclear reactions are brought about by the further contraction and heating of the inner parts of the star, after the hydrogen has been exhausted in the core. During this phase the outer layers of the star actually expand and cool, and the luminosity can become quite high. The star no longer resembles its former self when it was on the main sequence. It is now what astronomers call a giant, or, if the luminosity is extremely great, a SUPERGIANT.

Old Age and Death. Each stage of nuclear reactions produces heavier nuclei. When the old nuclei are exhausted, further contraction and heating of the inner parts of a star will ignite the heavier particles. In this way one can imagine helium-burning followed by carbon-burning, then oxygen-burning, then silicon-burning, and so on. As the giant or supergiant star ages, it builds up layers of successively heavier and heavier elements in its interior, with the heaviest materials in the core and the lighter materials in hierarchical shells around the core.

This process cannot go on indefinitely. The nuclear energy sources can become depleted, or a star can become unstable and blow itself apart, perhaps leaving a remnant behind. Finally, the material can become so dense that it resists further contractions, a state known as degeneracy.

If a star contracts to the point at which its electrons are degenerate and it can contract no further, it can get no hotter, and no new nuclear reactions can be initiated. The star will then slowly radiate away what heat energy it has available and will end its life as a cold, dark, degenerate body. Stars of this type exist and are known as WHITE DWARFS. The white dwarfs actually observed have not yet cooled to the point at which they would be dark and known as black dwarfs, which, of course, cannot be detected. The densities needed to produce electron degeneracy in stars are quite large. White dwarfs themselves have densities that are typically tons per cubic centimeter.

The electrons in a star cannot become degenerate if the star has a mass greater than about 1.4 times the mass of the Sun. This mass, known as the Chandrasekhar limit, is an upper limit for the mass of a white dwarf. Stars with masses greater than this limit may undergo violent explosions that eject much of their material into space. These explosions are called SUPERNOVAE.

The details of how a star becomes unstable and explodes as a supernova are not known. The core of the star apparently collapses with violence, driving off the outer layers and breaking down the core particles into neutrons. In several cases the remnants of supernova explosions have been detected. They are found to be NEUTRON STARS, composed of degenerate neutrons. Rotating neutron stars have been observed and are called PULSARS.

The neutron star, being degenerate, cannot contract further. Like a white dwarf, it will radiate away its excess energy and end its life as a cold, dark body. Neutrons are much more difficult to make degenerate than electrons, and neutron stars have densities that are billions of times greater even than those of white dwarfs. A neutron star is only a few kilometers in size, even though it may contain as much mass as the Sun.

There is a maximum mass for a neutron star, as for white dwarfs. If a star never sheds enough mass for either its electrons or its neutrons to become degenerate, there is nothing to stop continued contraction when the nuclear sources have been completely used up. The star will keep getting smaller until its entire mass is squeezed into such a tiny volume that it becomes an object known as a BLACK HOLE.

Stendhal [stan-dahl'] Stendhal was the pen name of the French novelist Henri Marie Beyle, b. Jan. 23, 1783, d. Mar. 23, 1842. Largely ignored during his lifetime by readers and critics alike, he has long since been recognized as a master psychological novelist.

The son of a well-to-do Grenoble lawyer, Stendhal was accepted (1799) by the Polytechnic Institute in Paris, but he dreamed of becoming a playwright instead of attending classes. An influential Parisian cousin obtained a commission for him in Napoleon's army in Italy, which introduced him to the land he was later to endow with mythic status. His administrative career under Napoleon provided him with first-hand knowledge of the occupation of Italy, the Prussian campaigns, and the burning of Moscow. On the collapse of the Napoleonic Empire, Stendhal decided to expatriate himself to Milan, where he remained from 1814 until he was obliged to leave in 1821 by the Austrian government, then reoccupying northern Italy.

Stendhal's return to Paris had been preceded by three works that established him as a writer: *The Lives of Haydn, Mozart, and Metastasio* (1814; Eng. trans., 1972), *Histoire de la peinture en Italie* (History of Italian Painting, 1817), and *Rome, Naples, and Florence* (1817; Eng. trans., 1959). Although the first two were largely plagiarized and the third was a seemingly superficial travel book, all three reveal an originality of mind. Stendhal's first autobiographical work, *On Love* (1822; Eng. trans., 1914)—masquerading as a treatise on love—analyzes the development of his unrequited passion for a Milanese lady. His *Life of Rossini* (1823; Eng. trans., 1956), although not the most reliable of biographies, remains the most perceptive to date.

Stendhal was one of the first to develop the cult of the self in literature. His *Promenades dans Rome* (Promenades in Rome, 1829) and *Memoirs of a Tourist* (1838; Eng. trans., 1962) established tourism not as the mere discovery of unfamiliar places but as the discovery of the self. The word *egotism*, launched in his *Memoirs of an Egotist* (1892; Eng. trans., 1949), denotes Stendhal's modern concept of self-analysis, rather than a portrayal of an idealized self. His approach to autobiography was not to reconstruct the past through a systematic recalling of episodes but to relive the sensations evoked by memory, reacting to them while writing as though he were the reader of his own works.

Best known for two novels, *The Red and the Black*

Stendhal, born Henri Marie Beyle, was a master of the French psychological novel. Best known for The Red and the Black *(1830) and* The Charterhouse of Parma *(1839), Stendhal also wrote several travel books and biographies of musicians.*

(1830; Eng. trans., 1898) and *The Charterhouse of Parma* (1839; Eng. trans., 1925), Stendhal wrote an earlier novel, *Armance* (1827; Eng. trans., 1928), that already suggested one of the themes that was to remain his constant preoccupation: the oppressive conformism of Restoration society. The individual against society is the major theme of *The Red and the Black*, whose title refers to the choices open to the hero: army or church, Jacobinism or reaction, courage or hypocrisy. *The Charterhouse of Parma* explores this theme again, but in the more exuberant atmosphere of fanciful history borrowed from the Italian Renaissance and the Napoleonic era, which confers on the characters the dynamism of epic heroes.

Stendhal returned to government service after the revolution of July 1830, being appointed to minor consular positions, first at Trieste, then at Civitavecchia, the port of Rome. He died in Paris following an apoplectic seizure.

Stengel, Casey [steng'-gul] Charles Dillon "The Old Professor" Stengel, b. Kansas City, Mo., July 30, 1890, d. Sept. 29, 1975, was an American professional baseball player and later a manager. Known as "Casey" Stengel, he compiled a .284 career batting average during his 14 years as a player. It was as a manager, however, that Stengel gained acclaim. He managed 4 teams over the course of 25 years, and with the New York Yankees, from 1949 to 1960, he won 10 pennants and 7 World Series titles. Stengel was the first manager of the New York Mets. Despite a losing record there, Stengel delighted the fans and the press with his antics and colorful personality. He was elected to the Baseball Hall of Fame in 1966.

stenography see SHORTHAND

Stephen, Saint Originally one of the seven deacons or "servers" chosen to assist the Apostles, Stephen, d. AD *c.*36, became an important preacher and the first Christian martyr. According to Acts 6–7, Stephen's charge before the Sanhedrin that the Jews had persistently disobeyed God so enraged his Jewish audience that they stoned him to death. Parallels drawn with the crucifixion of Jesus make the story of Stephen's death important in Christian tradition. Feast day: Dec. 27 (East); Dec. 26 (West).

Stephen Báthory, King of Poland see BÁTHORY (family)

Stephen Dušan, King of Serbia [doo'-shahn] Stephen Dušan, or Stephen Uroš IV, b. 1308, d. Dec. 20, 1355, who reigned (1331–55) as king of Serbia after deposing his father, Stephen Uroš III (r. 1322–31), brought Serbia to its height of power through his conquests. He seized part of western Macedonia from the Byzantine Empire in 1334 and in 1343 conquered Albania and more of Macedonia. Stephen had himself crowned emperor of the Serbs and Greeks in 1346. He captured (1348) Epirus and Thessaly and promulgated (1349, 1354) a law code. His empire collapsed, however, under his son and successor, Stephen Uroš V (1355–71).

Stephen, King of England Stephen, b. *c.*1097, d. Oct. 25, 1154, was king of England from 1135 to 1154. The son of Count Stephen of Blois and Chartres and Adela (daughter of King WILLIAM I of England), he was elected king on Dec. 22, 1135, succeeding his uncle HENRY I despite his earlier sworn fealty to MATILDA, Henry's daughter, as Henry's successor. Pleasant and congenial, Stephen lacked the ruthless determination requisite in a medieval king.

From 1135 to 1138 he established good relations with both the barons and the church, but then civil war broke out (1138) between him and Matilda, who was supported by the powerful earl of Gloucester, her half brother. Stephen was taken prisoner in 1141, and Matilda reigned briefly as "Lady of the English." After six months, however, she was forced to release Stephen, who resumed the throne. Never a competent leader, Stephen was unable to reestablish his authority, and during the next few years England was in virtual anarchy. Geoffrey died in 1147, and Matilda left England in 1148, thereby initiating a period of relative calm. Stephen was succeeded by HENRY II, Matilda's son. Although some recent historians have judged him less harshly, Stephen's contemporaries saw him as a reckless ruler in whose time there was only violence, disorder, and turbulence.

Stephen I, King of Hungary (Saint Stephen) Stephen I, or Saint Stephen, b. *c.*975, d. Aug. 15, 1038, was the first king of Hungary. Son of the supreme Magyar prince Géza, whom he succeeded in 997, Stephen was raised as a Christian. He suppressed a pagan revolt in 998 and in 1000 or 1001 was crowned king with the approval of Pope Sylvester II. Stephen established church institutions and replaced tribal land systems with individual proprietorship. He was succeeded on his death by Peter, his nephew. Canonized in 1083, Stephen is Hungary's principal national hero. Feast day: Aug. 16 (formerly Sept. 2; Aug. 20 in Hungary).

Stephens, Alexander Hamilton The American statesman Alexander Hamilton Stephens, b. Wilkes (now Taliaferro) County, Ga., Feb. 11, 1812, d. Mar. 4, 1883, was vice-president (1861–65) of the Confederate States of America, U.S. representative (1843–59, 1873–82) from Georgia, and governor (1882–83) of Georgia. He was a lawyer and a member (1836–42) of the Georgia legislature and later became a leading Southern Whig in Congress. Stephens supported the COMPROMISE OF 1850 and was instrumental in winning Southern support for it. He became a Democrat in 1852. Originally opposed to secession, Stephens swung behind his state when Georgia left the Union in January 1861.

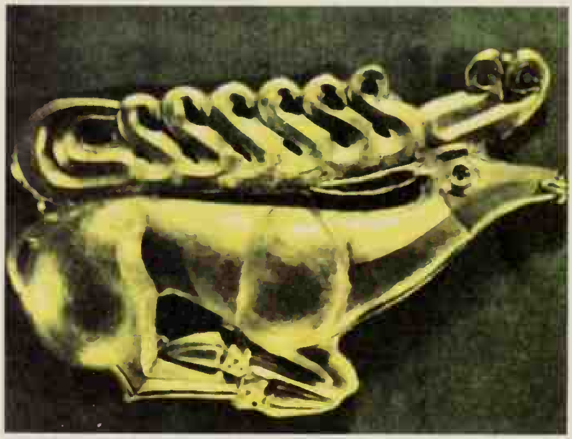
Stephens successfully urged adoption of a Confederate constitution similar to that of the United States. A rigid advocate of individual and state rights, he assailed President Jefferson Davis for backing conscription, martial law, and suspension of habeas corpus. His attacks did much to undermine Southern morale. At the end of the Civil War he was jailed for five months.

Stephenson, George and Robert George Stephenson, b. June 9, 1781, d. Aug. 12, 1848, and his son Robert Stephenson, b. Oct. 16, 1803, d. Oct. 12, 1859, were an English team of engineers and inventors who made major contributions to the first English LOCOMOTIVES and RAILROADS.

George Stephenson, extremely poor as a young man, worked in local collieries and taught himself to read and write in his spare time. He became (1812) a colliery engine builder, and in 1814 he built his first locomotive. When the Stockton and Darlington Railway was projected, George Stephenson was retained as company engineer. He convinced the owners to use steam motive power and built the line's first locomotive, the *Locomotion*. In 1825, Stephenson moved to the Liverpool and Manchester Railway. He and his son Robert built (1829) the ROCKET, which won the competition held to design a suitable steam locomotive for that railroad.

Robert Stephenson helped his father plan and build other railroads in England and on the Continent in the 1820s, and during the 1830s he was responsible for many improvements in locomotive design. He later became the builder of tubular girder railway bridges in England, Europe, and Canada.

steppe art Steppe art comprises the artistic traditions of the nomads who inhabited (7th–4th century BC) the prairies, or steppes, extending from eastern Europe to Siberia. Although the origins of steppe art are still unclear, some elements have been traced back to tribes who lived in Siberia during the 3d millennium BC. By the 7th century BC various steppe tribes had developed rich cultures that differed from tribe to tribe. All steppe art, however, had certain features in common. Because nomads had to carry their wealth with them, their artists concentrated almost exclusively on decorating useful objects and objects that could be worn by the owner or were easily portable, such as jewelry, weapons, cups, and bowls. Animals were the most common motif, and the so-called animal style was probably native to steppe art. Finally, the art of most steppe tribes had foreign elements of those higher civilizations, such as Persia, Greece, and China, with whom the nomads came into contact.



This Greco-Scythian gold stag reflects the refinement of Scythian metalwork. The Scythians, who inhabited (c.8th–4th century BC) the southern Russian steppes, produced significant pieces of art. (Hermitage, Leningrad.)

The most famous steppe art was that of the SCYTHIANS, who held sway (*c*.8th–4th century BC) over the steppes of what is now southern Russia. Judging from the large number of gold objects discovered in Scythian graves, this tribe seems to have been very wealthy. The great gold stag discovered as part of a shield decoration from Kostromskaya Kurgan, a burial mound in the northwestern Caucasus (*c*.600 BC; Hermitage Museum, Leningrad), reflects the high level of artisanship achieved by Scythian metal workers. East of the Scythian domains, nomadic art takes on a more primitive appearance and reflects the influence of Persian or Chinese, rather than Greek, culture. The finds from the Golden Kurgans in the Chiliktin valley of Kazakhstan include small gold-foil feline animals in coiled pose, stags, boars, and abbreviated vultures—all of which were used to decorate leather quivers. Fifth-century BC objects excavated at pazyryk and other sites in the Altai Mountains of Siberia are decorated in a simplistic version of the animal style that extends even to the tattoo preserved on the skin of one of the nomadic chiefs. The most mysterious collection of steppe art is the so-called treasure of Peter the Great, a heterogeneous collection of gold objects that probably was taken from graves somewhere in central Asia or Siberia.

steppe life Steppe generally refers to arid, temperate GRASSLANDS—often devoid of trees—of comparable vegetation, climate, soils, and topography to those of central Eurasia, although the term is often applied to grasslands of the Southern Hemisphere as well. The various local names include prairies (North America), pampas (South America), and veld (South Africa). In addition to being suited to a climate with distinct wet and dry seasons and long droughts, plant and animal life must be adapted to periodic, extensive fires and a flat-to-rolling terrain, physical characteristics common to all grasslands.

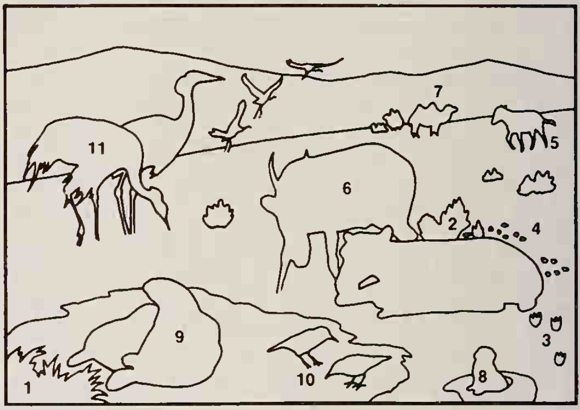
Steppe grasses, on which steppe life is totally dependent, dominate the vegetation except in areas with water near or at the surface, where numerous flowers of the sunflower, mint, and bean families intermingle with the grasses. The narrow leaves, extensive root systems, and heights attained by grasses make them well adapted to arid climates and habitats exposed to fire, drying winds, high light intensity, and high potential for evaporation and transpiration.

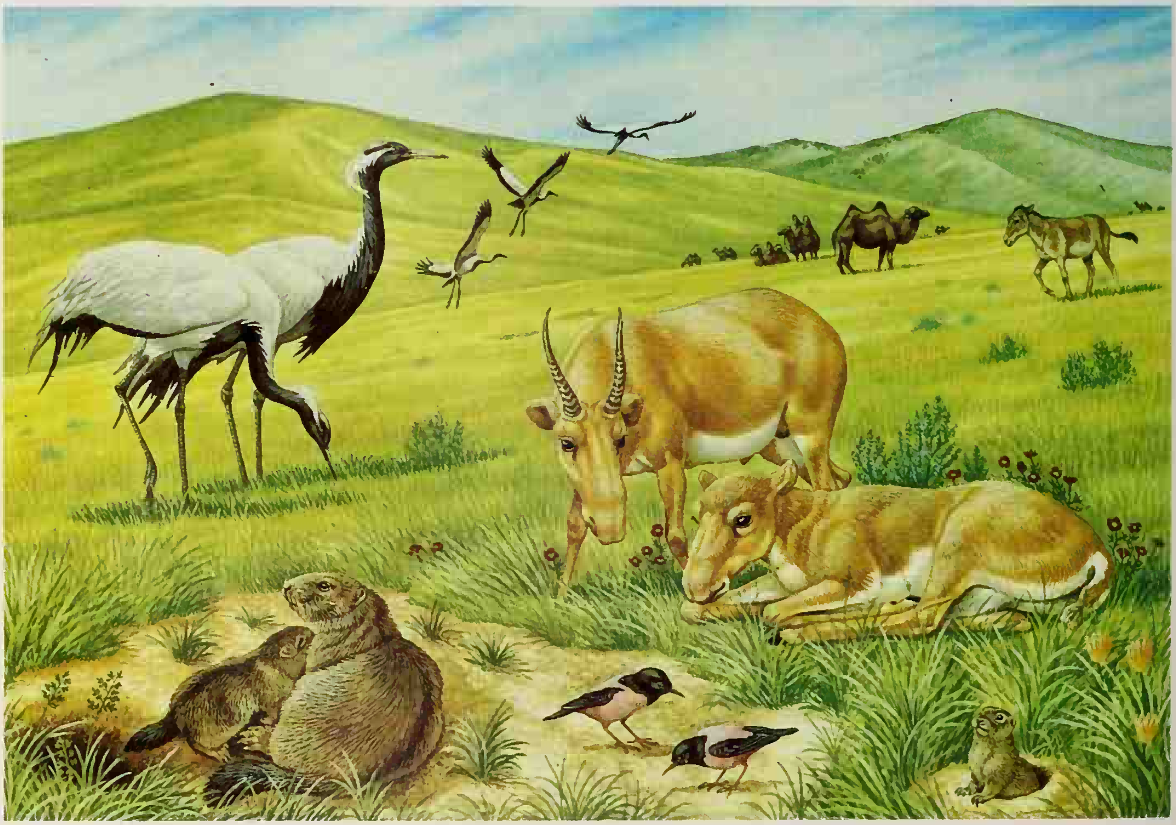
The vast steppes of Eurasia are dominated by several grass species, depending on local and regional conditions. Major dominants are feather grass (needlegrass), bromegrass, fescue, bluegrass (meadow grass), and wheatgrass. Several species of feather grass characterize the southern parts of Asia, where drought resistance allows them to dominate large areas.

Relatives of feather grass are common in the steppe region of Argentina (pampas). The life-form, however, is quite different in the pampas, as the grasses there form tall, solitary bunches called tussocks. Because they have a low grazing value for domesticated animals, they have largely been replaced by more palatable cultivated grasses. Domesticated plants and European animals have largely superseded the original grassland life of the pampas.

North American grasslands have grasses related to those of Eurasia, but the dominating ones are often warm-season grasses such as bluestems, switchgrass,

Steppes are immense, treeless plains of Eurasia in which hardy grasses are the predominant form of plant life. The Southernmost steppes are known as sage-and-grass, or nontillable, steppes, where the prevailing turf grasses include various species of bluegrass (1). *Bluegrass, which is nutritious and well adapted to arid climates, is an essential forage plant for much of the steppes' animal life. Other vegetation includes wormwood* (2), *shrubs that thrive in poor, dry soil; and the colorful wild tulips* (3) *and peonies* (4), *which bloom seasonally. Large herds of Asian wild asses* (5) *and antelopes such as the saiga* (6) *roam continuously in search of food and water as available sources are depleted. A few wild camels* (7) *are also found. Large colonies of rodents, such as susliks* (8) *and marmots* (9) *are also supported by the vegetation. Birds common to the steppes include the rose-colored starling* (10), *which breeds in large colonies once a year when migratory locusts appear; and the demoiselle crane* (11), *which builds its nest on the ground.*





and Indian grass where rainfall is higher (prairies). As more-arid conditions prevail (the plains), shorter plants such as grama grasses and buffalo grass provide the major food for grazing animals.

Throughout the world's steppes, salt accumulation on the soil surface results in a drastic shift in vegetation. Salts accumulate as rodents bring soil with high salt concentration to the surface, as salty water evaporates from the soil, and as shallow lakes dry. Plants that are tolerant of these salt concentrations are limited in number.

A remarkable array of herbivorous mammals inhabits the steppes. In Eurasia, for example, big, grazing ungulates (hoofed animals) such as wild horses, asses, and antelopes live in herds of long-range wanderers, following rainfall and tender grass. The saiga antelope is one of the most important grazers of the Eurasian steppes. During drought and hard winters, these animals wander endlessly, searching desperately for food and water, and large numbers die. Far greater in number but smaller in size are the many rodent species. Whereas the ungulates are readily seen, the chief consumers of the grass vegetation are the large colonies of rodents such as pocket gophers, rabbits, marmots, voles, and mice. By burrowing, rodents also contribute greatly to soil development and fertility and to biological activity in soils.

Bird life on the steppes is diverse and unusual. Some species, such as the bustards, demoiselle crane, sand grouses, and rose-colored starling of Eurasia, move in bands and live and breed in large groups. Generally, steppe birds are insect or grain eaters, and many species have expanded in numbers and range with the intense cultivation of cereal crops. Others have had their numbers reduced because their breeding and nesting sites have been eliminated by conversion of steppe to cultivated land.

The replacement of native herbivores with competing domestic sheep, goats, and cattle—and human occupation—has placed considerable survival pressure on large grazers in all steppe regions. In North America the bison almost became extinct in the 19th century because of overkill and habitat loss. It exists today only in managed herds, and domesticated cattle and sheep have replaced it in the grasslands.

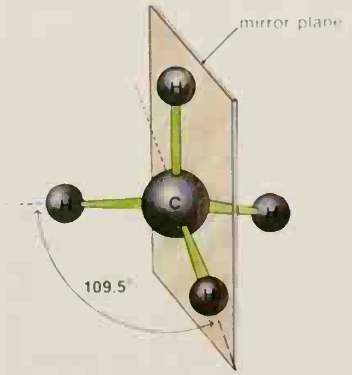
stereochemistry Stereochemistry is the study of the spatial arrangement of atoms in molecules and the effect thereof on the bulk properties and reactions of chemical compounds. In chemistry, stereochemical principles have become useful tools for determining the structures of compounds, for synthesizing highly complex molecules, and for revealing the details of chemical and biochemical reaction pathways. Stereochemistry is a special concern in the areas of biochemistry, biophysics, and drug development as well. On a molecular level, nearly all biochemical processes involve the spatial recognition of one molecule by another, and such recognition serves as the means by which energy and information are transmitted and complex biological structures are built.

As early as 1823, Friedrich Wohler and Justus Liebig recognized that two chemical compounds might have the same elemental composition yet differ in the order in which the atoms were linked together (see ISOMER). It was widely believed, until almost the end of the 1800s, that these criteria alone were enough to define completely a chemical compound. In 1848, however, the French scientist Louis Pasteur showed conclusively that two compounds could have the same order of linkage of individual atoms yet differ in certain of their physical and chemical properties. He laboriously obtained two forms of tartaric acid (a substance derived from wine) by handpicking differently shaped crystals from a mixture. These two forms, although identical in many respects, behaved differently toward POLARIZED LIGHT (see OPTICAL ACTIVITY), and only one of them could be used as a medium to grow molds. Arbitrarily, the molecule that rotates a beam of polarized light counterclockwise is termed *levorotatory* (*L*), and the one rotating light clockwise, *dextrorotatory* (*D*).

Tetrahedron. How the molecules of these two forms differed remained a mystery until, in 1874, Jacobus Hendricus van't Hoff and Joseph Achille Le Bel independently proposed that compounds having the same linkages of atoms could still differ in their CONFIGURATIONS, or arrangements of atoms in three-dimensional space. Compounds that differ in this way are called stereoisomers. Van't Hoff and Le Bel viewed the CARBON atom as occupying the center of a tetrahedron, in which the four vertices correspond to four atoms or groups attached to the atom. The concept of a tetrahedral carbon atom served as a foundation for further developments in the field of stereochemistry.

Asymmetric Carbon Atom. If any two groups attached to a carbon are alike, such as the two hydrogens in propionic acid, a plane of symmetry can be seen to pass through the atom so that one side of the molecule is the mirror image of the other. If all four groups are different, as in lactic acid, no such symmetry exists, and the carbon atom may be said to be asymmetric. Atoms other than carbon may serve as asymmetric centers by meeting the same criteria.

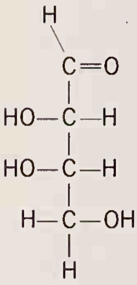
Enantiomers. Van't Hoff recognized that the presence of an asymmetric center in a molecule would give rise to two isomeric structures, called enantiomers, one of which is the exact mirror image of the other. Such a situation exists for optical isomers of tartaric acid and of lactic acid



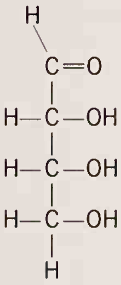
The tetrahedral arrangement of bonded atoms or groups around a carbon atom forms the basis of concepts in stereochemistry. The carbon atom (C) is situated in the center of the tetrahedron, and the four other atoms or groups, in this case hydrogen (H), form angles of 109.5° to each other. The tetrahedron can be divided along a plane through the carbon atom and two other atoms.

as well. Optical isomers are distinct chemical compounds; a molecule of this sort is often said to be chiral. The ultimate proof of chirality is found when the structure of a compound cannot be superimposed on its mirror image. One enantiomer always has the opposite effect on polarized light as the other; a racemic, or equal, mixture of the two is therefore optically inactive and often behaves physically as a single substance.

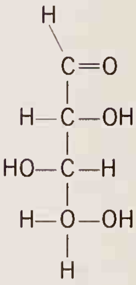
Other Isomers. Molecules with more than one asymmetric center may differ in configuration at any or all of these centers, affording multiple isomers. Examples of this are the following sugars:



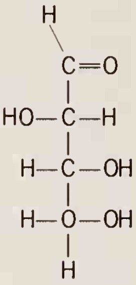
L-erythrose



D-erythrose



L-threose

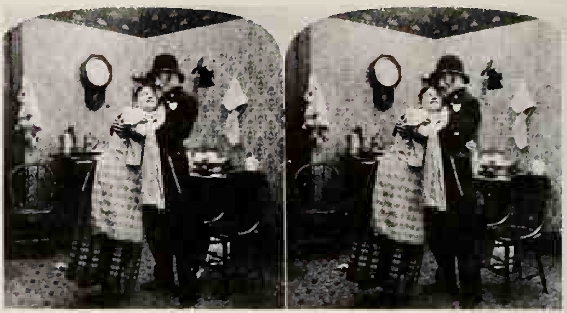


D-threose

Diastereomers are isomers that are not mirror images of each other, such as *L*-erythrose and *L*-threose. Van't Hoff also correctly predicted that the spatial arrangement of groups around a planar double bond could give rise to stereoisomers known as geometric, or cis-trans, isomers.

Different spatial arrangements of a molecule that can be interconverted by rotation around single bonds are called conformational isomers, or conformers. The study of conformers represents the ultimate extension of stereochemistry because it deals most closely with the actual shapes of molecules. It provides a unique view of structure and bonding and allows prediction of the rates and products of reactions.

stereophonic sound see SOUND RECORDING AND REPRODUCTION



(Above) *This scene is typical of the stereoscopic photographs popular during the late 1800s. The paired slides were made by a camera with two lenses set 6.4 cm (2.5 in) apart, the approximate distance between human eyes.*

(Right) *A stereoscopic viewer resolved the two views into one, giving the illusion of three-dimensional vision. The London Stereographic Company, whose slogan was "No home without a stereoscope," sold viewers for less than a dollar, together with prepared slides.*

stereoscope The stereoscope, an optical device invented by Charles Wheatstone in 1838, enables the simultaneous viewing of two slightly different photographs. Because human eyes are separated by a slight distance, the object being viewed appears slightly different to each eye; this effect provides a sense of depth. In the Wheatstone stereoscope, right- and left-monocular pictures are projected to the two eyes so that the optic axes converge at the same angle; as a result, the pictures give the impression of a solid image. Wheatstone accomplished this convergence by using a mirror system. In 1849, David Brewster invented the improved refracting, or lenticular, stereoscope and a twin camera, which had two separate cameras placed at a slight distance from each other. The twin camera provided near-perfect right- and left-monocular pictures that, when viewed through a stereoscope, appear in three-dimensional realism. The stereoscopic principle is also used in range finders, binoculars, and stereoscopic microscopes.

stereotype Stereotypes are the oldest and cheapest type of duplicate plate for letterpress PRINTING. They were once used extensively for printing large newspaper runs and to some extent in book printing and the production of short-run trade magazines. They were practical for coarse-screen halftones, line plates, and type forms. A mold, called a matrix or mat, was made from the original type or engraving using a special papier-mâché, and the printing plate was cast by pouring molten lead into this mold. For long press runs the lead plates could be nickel or chromium plated. Once the mat was made, duplicate plates could be produced in less than a minute. Because most newspapers have converted to lithographic printing and photopolymer plates, the use of stereotype plates is almost at an end.

sterility see FERTILITY, HUMAN

Stern, Isaac The Russian-born violin virtuoso Isaac Stern, b. July 21, 1920, was brought to San Francisco while still an infant. He made his professional debut at the age of 11 with the San Francisco Symphony and rapidly built a career as a concert soloist. Stern is equally at home performing the standard works for violin and playing contemporary compositions, and he established his reputation in chamber music in a trio with pianist Eugene Istomin and cellist Leonard Rose. Stern's long, close association with Carnegie Hall is noteworthy.

Sternberg, Josef von The films of Austrian-American director Josef von Sternberg, pseudonym of Jonas Stern, b. Vienna, May 29, 1894, d. Dec. 22, 1969, are perhaps the supreme example of the narrative film's pursuit of visual beauty at the expense of dramatic values. Sternberg had his first popular success with *Underworld* (1927), which was followed by *The Docks of New York* (1928) and *Thunderbolt* (1929). He then went to Germany to direct *The Blue Angel* (1930), a sensational success that inaugurated the director's long association with his "discovery," Marlene DIETRICH. Their early films together—*Morocco* (1930), *Dishonoured* (1931), and *Shanghai Express* (1932)—displayed the visual dynamism that distinguished Sternberg's previous work, but this gradually gave way in *The Scarlet Empress* (1934) and *The Devil Is a Woman* (1935) to increasingly static glorifications of Dietrich's mystique. Of his later films, only *The Shanghai Gesture* (1941) and *Anatahan* (1953) are notable.

sternbergia [sturn-bur'-gee-uh] *Sternbergia* is a genus of about five species of bulbous herbs in the amaryllis family, Amaryllidaceae, and native to Eurasia. The winter daffodil, or lily-of-the-field, *S. lutea*, mentioned in the Bible, produces waxen, golden yellow flowers in autumn and grows in dry rocky areas.

Sterne, Laurence The author of one of the most original and profound English novels of the 18th century, Laurence Sterne b. Clonmel, Ireland, Nov. 24, 1713, d. Mar. 18, 1768, found himself famous overnight after publishing the first two volumes of *The Life and Opinions of Tristram Shandy, Gentleman* (1760). He went on to add seven more volumes (in 1761, 1765, and 1767) to the work, which is both a richly comic novel and an ingenious parody of the novel form.

The son of an army officer, Sterne attended Jesus College, Cambridge, and in 1738 became vicar of Sutton-in-the-Forest, Yorkshire. He spent most of his life as a country parson and gentleman farmer. His marriage in 1741 proved unhappy, and he was involved with a number of other women, for one of whom—Mrs. Eliza Draper—he wrote what is now known as *Journal to Eliza* (1767). Sterne was also active in local ecclesiastical politics, held an office in the cathedral at York, and achieved some success as a preacher. All this experience is reflected in TRISTRAM SHANDY.

Although Sterne was influenced by older satirists, such as Rabelais, Cervantes, and Swift, *Tristram Shandy* is loosely based on John LOCKE's theory of the association of ideas. Characters are therefore presented by means of their emotions and impressions rather than through external incidents, and because no two characters have the same associations, comic confusions abound when communication is attempted.

Although attacked on moral and literary grounds by some for its deliberate incoherence and its sexual humor, *Tristram Shandy* was an immense success and made Sterne a literary celebrity, so much so that he published several collections of his sermons as *The Sermons of Mr. Yorick* (1760, 1766, 1769). Sterne went abroad for his health in 1762, and in 1768 he published *A Sentimental Journey through France and Italy*, a series of comic and touching anecdotes based on his travels. He died of pleurisy.

steroid [stair'-oyd] Steroids are fat-soluble (lipid) organic compounds that occur naturally throughout the plant and animal kingdoms and play many important functional roles. All steroids are characterized by a four-ring structural configuration. Steroids are quite diverse and include the sterols (such as CHOLESTEROL) of vertebrates, bile acids from the liver, all sex hormones, adrenocortical hormones (corticosteroids), toad poisons, and products of the DIGITALIS plant used to treat heart disease. Hormonal steroids are synthesized from cholesterol in the body. The biosynthetic mechanisms are similar in all steroid-secreting tissue (adrenal cortex, testis, ovary, and placenta).

Whereas sex hormones are necessary for many aspects of reproduction and sexual function, the adrenocortical hormones, secreted by the adrenal cortex, are essential to life itself. There are two classes of corticosteroids. The glucocorticoids such as cortisone affect primarily carbohydrate and protein metabolism. They have limited use in the treatment of many immunologic and allergic diseases, such as arthritis. The mineralocorticoids such as aldosterone regulate principally salt and water balance. Because of the great therapeutic value of corticosteroids, many synthetic steroids have been produced, some more potent than the natural hormones. Synthetic steroids include antiinflammatory drugs, oral contraceptives, and a synthetic adrenal steroid used to treat ADDISON'S DISEASE.

Anabolic steroids are derived from the sex hormone testosterone. Developed in the 1930s, they came to public notice following World War II, when they were used to restore body weight in concentration camp survivors. They were later promoted for use against many conditions, but research did not support most such claims; remaining recognized uses include the treatment of certain anemias and breast cancers. Since the early 1950s the drugs have also come to be widely employed by athletes in the hope of enhancing performance (see SPORTS MEDICINE), despite efforts to discourage or ban the practice. Short-term and apparently reversible side effects include acne, balding, reduced sex drive, increased irritability, and (in women) masculinization. Long-term effects such as liver tumors and changes in liver function, also apparently reversible, are known, and some athlete deaths from steroids have been reported. In children the drugs can cause long bones to fuse prematurely and can induce premature puberty.

sterol [stair'-awl] Originally the name of the entire steroid class of lipids, the term *sterol* is now used more specifically for chemically similar compounds having a hydroxyl group (OH) attached to a series of fused rings. In vertebrates the principal sterol is CHOLESTEROL, which is especially abundant in nerve tissue and gallstones. Ergosterol, a sterol found in yeast, ergot, and molds, gives rise to vitamin D_2 (calciferol) when irradiated with ultraviolet light. In higher plants, the principal sterols have 29 carbon atoms. Only a few sterols are absorbed and transferred to the circulation, and although cholesterol is readily absorbed, it is not an essential component of the diet. Most animals can synthesize their necessary sterols from smaller carbon compounds.

stethoscope The stethoscope is an instrument used in medical diagnosis by physicians (often in combination with light tapping on the chest) to listen to sounds emitted from internal organs, a practice called auscultation. The first stethoscope, a hollow wooden tube, was invented by the French physician René T. H. Laënnec (1781–1826) in the early 1800s. One end had a broad opening, which was placed against the patient's chest. The physician could hear sounds of breathing and of heart action by placing one ear against the opposite, narrow opening. The more conventional stethoscope was designed in the early 1900s by the American physician George P. Cammann (1904–63). It consisted of two flexible rubber tubes connected to earpieces at one end and to a chest piece on the other. Both ears could now be used to listen to the sounds. The chest piece is of two types. One is a bell-shaped metal cone that transmits low-pitched sounds, whereas the other is a diaphragm that transmits high-pitched sounds. Both types of chest pieces are commonly used to evaluate the cardiac and pulmonary systems by allowing physicians to distinguish clearly the sounds that the beating heart generates, as well as the sounds of gas exchange in the lungs. With proper training, doctors can diagnose many types of disease processes of the heart and lungs, as well as of the stomach and blood vessels.

Stettheimer, Florine [stet'-hym-ur] Florine Stettheimer, b. Rochester, N.Y., Aug. 19, 1871, d. May 11, 1944, became the most noted artist in her artistic family. She painted witty scenes of circuses, parties, and celebrations with small, graceful figures in detailed, fanciful settings. Stettheimer studied at the Art Students League and, accompanied by her family, lived for a time in Europe. After returning to New York, the Stettheimers entertained Marcel Duchamp, Alfred Stieglitz, and other people who appear in Stettheimer's paintings. These works, full of decorative, bright colors, are given coherence by calligraphic white accents; an example is *Cathedrals of Art* (1942; Metropolitan Museum, New York City).

Stettinius, Edward Reilly, Jr. [stuh-tin'-ee-uhs] Edward Reilly Stettinius, Jr., b. Chicago, Oct. 22, 1900, d. Oct. 31, 1949, served (1944–45) as U.S. secretary of state. An executive at General Motors and U.S. Steel during the 1930s, he entered government service in 1940 and was undersecretary of state from 1943 to 1944. As secretary of state, he helped establish the United Nations and in April 1945 headed the U.S. delegation to the founding conference of the world organization in San Francisco. Stettinius represented the United States at the United Nations from January to June 1946.

Steuben, Friedrich Wilhelm, Baron von [stoo'-ben or shtoy'-ben] During the American Revolution a German officer, Friedrich Wilhelm Augustin, Baron von Steuben, b. Magdeburg, Prussia, Sept. 17, 1730, d. Nov. 28, 1794, helped instill discipline in the Continental Army through his drilling techniques. A Prussian officer in the Seven Years' War, he went to America in 1777 and was appointed inspector general of the Continental Army with the rank of major general. His *Regulations for the Order and Discipline of the Troops of the United States* (1779) was used by the army until the War of 1812.

Steuben glass [stoo'-ben] Steuben glass was first produced in 1903 at the Steuben Glass Works in Corning, N.Y., directed by Arthur Amory Houghton. In 1918 the company became a division of the Corning Glass Works. The work of the English glassmaker Frederick Carder, who was the chief designer from the beginning until 1934, was influenced largely by the ART NOUVEAU style. Among Carder's creations were aurene (an iridescent glass in blue and gold luster), colored opalines (in light rose, jade green, translucent white, and shades of blue), clear glass combined with colors, and pressed glass. By 1933 the Steuben company had achieved an international reputation for its blown and engraved glass and many artists were brought in to create one-of-a-kind presentation pieces of engraved crystal.

Stevens (family) The Stevens family is best known for three American inventors who were pioneers in the development of STEAMBOAT and RAILROAD transportation in the United States. **John Stevens**, b. New York City, 1749, d. Mar. 6, 1838, was an engineer and one of the earliest proponents of steam power in transportation. After studying law (1768–71) he became interested in steam navigation in the late 1780s. He began to seek (1792) patents for his improved boiler and engine designs. In 1809 the *Phoenix*, a paddle-wheel steamboat designed by Stevens, sailed from New York City to Philadelphia—the first ocean voyage ever taken by a steamboat. In 1815, Stevens obtained the first U.S. railroad charter. In 1826 he designed and built the United States' first steam LOCOMOTIVE but operated it only on a circular track on his estate in Hoboken, N.J.

The second son of John Stevens, **Robert Livingston Stevens**, b. Hoboken, Oct. 18, 1787, d. Apr. 20, 1859, was a mechanical engineer and inventor. Interested in naval architecture, he helped his father design the *Phoenix*. Associated with his father's railway plans, R. L. Stevens invented (1830) the T rail.

Edwin Augustus Stevens, b. Hoboken, July 28, 1795, d. Aug. 7, 1868, the sixth son of John Stevens, was an engineer, financier, inventor, and philanthropist. He bequeathed money and land to found the Stevens Institute of Technology in Hoboken.

Stevens, John P. John Paul Stevens, b. Chicago, Apr. 20, 1920, was sworn in by Chief Justice Warren Burger as associate justice of the U.S. Supreme Court on Dec. 19, 1975, replacing the retired William O. Douglas. Stevens graduated (1941) from the University of Chicago, served in the navy, and received (1947) a law degree from Northwestern University. He clerked (1947–48) for Supreme Court Justice Wiley B. Rutledge and then began to practice law in Chicago. President Richard M. Nixon appointed him a judge of the U.S. Court of Appeals for the Seventh Circuit in 1970. On the U.S. Supreme Court, Stevens's position has been moderately conservative.

Stevens, Thaddeus Thaddeus Stevens, b. Danville, Vt., Apr. 4, 1792, d. Aug. 11, 1868, U.S. representative from Pennsylvania (1849–53, 1859–68), was one of the most influential Radical Republican leaders in the U.S. Congress during the RECONSTRUCTION era. From the 1820s on, Stevens was active in politics—as an Anti-Mason, a Whig, a Know-Nothing, and finally a Republican. Serving in the Pennsylvania legislature between 1833 and 1841, Stevens acquired a reputation as the moving force behind the passage of Pennsylvania's free public school law and as a radical opponent of slavery.

Stevens served as an antislavery Whig during his first 4 years (1849–53) in Congress. In the election of 1858 he held on to his congressional seat as Civil War issues swept the Republican party to power; he subsequently sat as a Republican. In 1861 he became chairman of the House of Representatives' most important committee, Ways and Means, and thus the recognized leader of House Republicans.

The U.S. representative Thaddeus Stevens was a militant opponent of slavery. A leader of the Radical Republicans during Reconstruction, he was instrumental in securing passage of the 14th Amendment and managed the impeachment of President Andrew Johnson.

His greatest impact was on the development of Reconstruction policy. During the Civil War he pressed for vigorous antislavery measures and stringent terms for Reconstruction. After the Confederate surrender, Stevens broke with President Andrew Johnson over Johnson's lenient Reconstruction program, advocating instead a far more rigorous policy of political, educational, and economic reform. He was unable to secure his own radical program, but as a leader of Congress's Joint Committee on Reconstruction he was instrumental in obstructing Johnson's plan and in establishing one based on legal and political equality for southern blacks.

In 1868, Stevens was a House manager (prosecutor) in the president's impeachment trial before the Senate. That year he died embittered by Johnson's acquittal.

Stevens, Wallace Wallace Stevens, a major 20th-century American poet, devoted his literary energies to an exploration of the possible relations between reality and imagination. His lifelong concern with the bearing of language on the philosophical problem of knowledge has led many to find Stevens's closest intellectual relatives among such phenomenological thinkers as Martin Heidegger and Charles Sanders Peirce rather than among other poets.

Stevens, b. Reading, Pa., Oct. 2, 1879, d. Aug. 2, 1955, was an elusive and unconventional poet but lived a conventional and uneventful life. He studied at Harvard University and New York University Law School. He joined the Hartford Accident and Indemnity Company in 1916, and in 1934 he became vice-president, a position he held until his death.

Apart from some verse in the *Harvard Advocate*, Stevens published nothing until 1914, when his work was featured in *Poetry* magazine. *Harmonium* (1923), his first volume, contains many of Stevens's most famous poems. Between 1923 and 1933, he was again silent, but in 1934 he began working strenuously. He soon published his second volume, *Ideas of Order* (1936); a long poem, "Owl's Clover" (1936); and a third volume, *The Man with the Blue Guitar* (1937). Whereas Stevens's imagination had formerly evaded "the pressure of reality" by means of elaborate verbal structures, it began in the 1930s to define and control this reality. His work of this period culminates in *Notes toward a Supreme Fiction* (1942), a long and difficult poem that attempts to find the requirements of an idea capable of redeeming the mundane facts of ordinary life.

Wallace Stevens wrote complex, meditative poems exploring the constantly changing relationship between the world of reality and the creations of the imagination. To Stevens, the effort to comprehend this relationship was the modern equivalent of religious faith.

Stevens's next volumes were *Parts of a World* (1942; rev. ed. 1951), *Transport to Summer* (1947), and *The Auroras of Autumn* (1950). *The Collected Poems* (1954) won the National Book Award and the Pulitzer Prize. *Opus Posthumous*, the uncollected poems, appeared in 1957, *The Letters of Wallace Stevens* in 1966, and the notebooks, entitled *Souvenirs and Prophecies*, in 1977. Stevens put together only one small (but important) volume of criticism, *The Necessary Angel* (1951), but theoretical considerations of poetry are common throughout his poetical works. Although he had moods of grave doubt, Stevens's general confidence in the power of the imagination continued to grow in his last works. In "The Rock," his final major work, he pictured reality as a barren rock and attempted to make it a source of energy for the imagination.

Stevenson (family) The Stevensons, a leading family in American politics, have long been active as Illinois Democrats. **Adlai Ewing Stevenson**, b. Christian County, Ky., Oct. 23, 1835, d. June 14, 1914, was an Illinois lawyer who served in the U.S. House of Representatives and was vice-president of the United States under President Grover Cleveland from 1893 to 1897.

His grandson **Adlai Ewing Stevenson II**, b. Los Angeles, Feb. 5, 1900, d. July 14, 1965, a Chicago lawyer, became involved in the Council on Foreign Relations and the anti-isolationist Committee to Defend America by Aiding the Allies. During World War II he worked in the Navy and State departments. Elected governor of Illinois in 1948, he was drafted twice by the Democrats as their presidential nominee, in 1952 and in 1956. Stevenson was a gifted speaker but was no match for the popular Republican candidate, Dwight D. Eisenhower, who beat him handily in both of his attempts for the presidency.

The U.S. statesman Adlai Stevenson II vaulted into national prominence through his single term as Democratic governor of Illinois. He was twice nominated (1952, 1956) as his party's presidential candidate, losing both elections to Dwight D. Eisenhower.

Stevenson tried to win the presidential nomination a third time in 1960 but lost to John F. Kennedy, who named him ambassador to the United Nations. Although restive in that capacity, Stevenson backed the Democratic administration's policies and served until his sudden death in 1965.

His eldest son, **Adlai Ewing Stevenson III**, b. Chicago, Oct. 10, 1930, also practiced law and served as a Democratic U.S. senator (1970–81); he lost his 1982 and 1986 bids for the Illinois governorship, however.

Stevenson, Robert Louis The Scottish novelist, travel writer, poet, and essayist Robert Louis Stevenson, b. Edinburgh, Nov. 13, 1850, d. Dec. 3, 1894, was the author of the enduringly popular romantic adventure stories TREASURE ISLAND and *Kidnapped* (1886) and the alarming psychological allegory DR. JEKYLL AND MR. HYDE.

The son of a prosperous engineer, Stevenson was expected to pursue his father's profession despite his ill health. As a student at Edinburgh University he took up law, declared himself an agnostic, and began to write. An attack of tuberculosis, which plagued Stevenson all his life, prompted his first extensive trip to France, in 1873. *An Inland Voyage* (1878) and *Travels with a Donkey in the Cevennes* (1879) were both inspired by journeys taken during these years.

In 1875, Stevenson qualified as a lawyer, but he had also reached a wide audience through his essays in the *Cornhill Magazine*. Many of these pieces appeared in *Virginibus Puerisque and Other Papers* (1881). In 1876, Stevenson met Fanny Osbourne. She returned to California in 1878, and in the following year Stevenson decided to join her. After an arduous journey, described in *Across the Plains* (1892) and *The Amateur Emigrant* (1895), he reached San Francisco, penniless and in bad health. Their marriage in 1880, however, marked the beginning of his most productive period. During their extensive travels Stevenson produced a constant stream of romances, essays, and poems: *Treasure Island*, begun as a boys' serial called *The Sea-Cook* (1881), was completed in the Swiss resort of Davos; *A Child's Garden of Verses* (1885) was begun in France; and *Dr. Jekyll* was written in England. Returning to the United States in 1887, Stevenson began another historical romance, *The Master of Ballantrae* (1889).

By now a critically and commercially successful writer, Stevenson and his wife sailed from San Francisco to the islands of the South Pacific in 1888. He overcame his illness while in the tropics and delighted in the Marquesas Islands, Honolulu, and Samoa, which he described in

Robert Louis Stevenson, a versatile Scottish writer, was a leading figure of the "romantic revival" in Victorian literature. Stevenson is most famous for his horror story, The Strange Case of Dr. Jekyll and Mr. Hyde *(1886), and for two novels of adventure,* Treasure Island *(1881–82) and* Kidnapped *(1886).*

A Footnote to History (1892) and *In the South Seas* (1896). Samoa became his permanent home in 1890. He died there before completing what many critics have called his finest work, *Weir of Hermiston* (1896).

Stewart, Jackie John Young "Jackie" Stewart, b. June 11, 1939, was the premier British racing car driver of the late 1960s and early 1970s. He started competitive driving in 1962, and in 1965 he entered his first Grand Prix race in South Africa, where he finished sixth. His first Grand Prix victory was at Monza in 1965, and the next year he led for many laps in the Indianapolis 500 race before his car broke down. Stewart captured the world championship in 1969, 1971, and 1973. He retired just before the 1973 U.S. Grand Prix, when his racing teammate, François Cevert, was killed during practice.

Stewart, James Tall and gangly, with an inimitable drawl, film star James Maitland Stewart, b. Indiana, Pa., May 20, 1908, exuded such sincerity that he could never play a villain. He was probably at his best in such optimistic Frank Capra films as *You Can't Take It With You* (1938), *Mr. Smith Goes to Washington* (1939), and *It's A Wonderful Life* (1946). He was equally engaging playing drunks in *The Philadelphia Story* (1940), for which he won an Academy Award, and *Harvey* (1950). Stewart also gave memorable performances in *Destry Rides Again* (1939), *Rear Window* (1954), and *Anatomy of a Murder* (1959).

James Stewart, as Elwood P. Dowd, appraises his portrait in a scene from Harvey *(1950). Stewart's distinctive drawl and awkward mannerisms project a sincerity that has made him a Hollywood favorite since the 1930s.*

Stewart, Mary Mary Stewart is the pseudonym of Florence Elinor Stewart, b. Sept. 17, 1916, an English writer of adventure romances whose literate prose, crisp observation, and believable heroines have gained her a huge following. Of Stewart's novels, *My Brother Michael* (1960), *The Ivy Tree* (1961), *The Moon-Spinners* (1962; film, 1964), *Airs above the Ground* (1965), and *The Gabriel Hounds* (1967) are among the best. A trilogy consisting of *Crystal Cave* (1970), *The Hollow Hills* (1973), and *The Last Enchantment* (1979) explores the legend of Merlin. Other works are the children's book *A Walk in Wolf Wood* (1980) and *The Wicked Day* (1983).

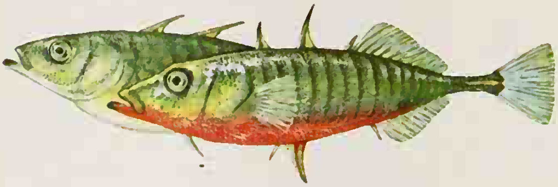
Stewart, Potter Potter Stewart, b. Jackson, Mich., Jan. 23, 1915, d. Dec. 7, 1985, served as a U.S. Supreme Court justice from 1958 until his resignation in 1981. A 1941 graduate of Yale Law School, he practiced law both before and after World War II service with the U.S. Naval Reserve. He then settled (1947–54) in Cincinnati, Ohio, where he served on the city council (1950–53) and as vice-mayor (1952–53). In June 1954 he became a judge of the U.S. Court of Appeals, Sixth Circuit. Appointed to the Supreme Court by President Dwight D. Eisenhower, the moderate Stewart was characterized as a "swing man," one who usually cast the decisive vote in an otherwise split court.

stibnite [stib'-nyt] The antimony SULFIDE MINERAL stibnite (Sb_2S_3) is the chief ore of antimony. It forms bladed or columnar masses or radiating elongated pyramids (orthorhombic system) that have several cleavage planes. The color and streak are metallic lead gray on fresh surfaces, but they soon tarnish and blacken. Hardness is 2, and specific gravity is 4.5 to 4.6. Although widely distributed, stibnite is relatively rare. It usually occurs in quartz veins, where it has been deposited from near-surface alkaline solutions, but has been found in replacement and hot-spring deposits and near deep intrusions of igneous rock.

stick insect Stick insects, or walking sticks, family Phasmatidae, order Orthoptera, are plant-feeding insects so named because they are very long and slender and resemble sticks or twigs. Most species are wingless. Stick insects are found mainly in the tropics, reaching a length of up to 35 cm (14 in). Those found in the southern United States reach 170 mm (7 in) in length. Some walking sticks, when disturbed, emit a foul-smelling substance from glands in the thorax.

stickleback Sticklebacks, family Gasterosteidae, are a group of teleost (bony) fishes from fresh, brackish, and shallow marine waters of the Northern Hemisphere. They are small (8–18 cm/3–7 in), elongate fishes, usually with bony plates along the body. Their color is usually green to black and silver underneath. Because the number of plates and several other characteristics vary with environmental factors—for example, temperature and salinity—the number of species placed in the two largest genera, *Gasterosteus* and *Pungitis*, has been a source of controversy.

Males develop a red "throat" at the beginning of the breeding season. They select and defend a territory against other males. In the middle of his territory a male will construct a nest out of plant material cemented together by a secretion from his kidneys. When a female loaded with eggs enters the territory, she is courted by the male. The female reacts to the zigzag dance of the male by allowing him to guide her to the nest. She enters the nest and the male induces her to lay eggs by butting her flank with his snout. The female leaves the nest, and the male enters and fertilizes the eggs. He then continues to guard his territory and cares for both the eggs and, when they hatch, the young sticklebacks.



The three-spined stickleback (or tiddler) is found throughout the Northern Hemisphere. The stickleback is an inshore marine fish that also is found in unpolluted fresh water.

Stiegel, Henry William [stee'-gul] Henry William Stiegel, b. Cologne, Germany, May 13, 1729, d. Jan. 10, 1785, was an ironmaster and glassmaker in the United States whose name is associated with prized American glassware. Stiegel emigrated to Philadelphia, Pa., when he was 21. Eight years later he and some partners bought an ironworks in Lancaster County, Pa., and prospered by manufacturing stoves, soap kettles, iron castings, and sugar-making equipment. In 1764, Stiegel constructed a glass factory that produced the colored glassware that today is called Stiegel glass, as well as sheet and window glass. The firm lasted only until 1774, when Stiegel went bankrupt.

Equivalent, Mountains and Sky, Lake George *(1924) is one of the cloud studies Alfred Stieglitz termed equivalents, in which he expressed his personal philosophy: "My cloud photographs are equivalents of my most profound life experiences." (Private collection.)*

Stieglitz, Alfred [steeg'-lits] The principal American force behind the recognition of photography as a fine art, Alfred Stieglitz, b. Hoboken, N.J., Jan. 1, 1864, d. July 13, 1946, was an outstanding champion of the avant-garde in all the visual arts. Trained in photographic technology in Berlin from 1883, Stieglitz first made his mark as an amateur photographer of technical excellence whose genre subjects passed beyond the anecdotal to penetrate the meaning of the scene itself.

In 1890, Stieglitz began promoting amateur photography as of higher quality than the routine, unimaginative work produced by his professional contemporaries. As the editor of *American Amateur Photographer* (1893–96) and of *Camera Notes* (1897–1902) he gained international recognition for such soon-to-be-famous American photographers as Gertrude Käsebier, Edward Steichen, and Clarence H. White. Influenced by avant-garde movements in Germany, Stieglitz organized (1902) an impressive display of the finest pictorial photography at the National Arts Club in New York, an exhibition that gave rise to the artistic group of photographers known as the Photo-Secession. Stieglitz published the work of this group in *Camera Work* from 1903 to 1917.

In 1917 he closed the exhibition galleries to devote himself to photography but again from 1925 to 1947 directed two galleries, first The Intimate Gallery, then An American Place, where he exhibited the photography of Ansel Adams, Eliot Porter, and Paul Strand and paintings by leading American artists. Of his own work, his famous serial portraits of the painter Georgia O'Keeffe, whom he married in 1924, and his cloud studies, called *Equiva-*

lents (*c.*1929), represent the most intimate expressions of his response to the world around him.

stigmata [stig-maht'-uh] Stigmata are bodily marks resembling the wounds suffered by Jesus Christ when he was crucified. They are manifested on the hands, on the feet, near the heart, and on the head and shoulders. The stigmata are not usual bodily lacerations, do not deteriorate in the usual fashion of wounds, and are not susceptible to medical treatment. More than 330 cases are known of Christians who have been stigmatized. In many cases stigmatization can be explained by natural causes such as the physical and psychic conditions of the person, along with a strong interest in and devotion to the sufferings of Christ. Sixty stigmatics whose lives have been marked by great holiness and mystical experiences have been either canonized or beatified. FRANCIS OF ASSISI was the first and best-known saint to receive stigmata.

stilbite see ZEOLITE

Stiles, Ezra A Congregational minister and the seventh president of Yale College, Ezra Stiles, b. North Haven, Conn., Dec. 15, 1727, d. May 12, 1795, was recognized as the most learned man of his time in New England. He was an articulate moderate in ecclesiastical matters and a Patriot in politics. In 1740 he formed a society to promote the freedom of slaves.

Stilicho, Flavius [stil'-i-koh] Flavius Stilicho, b. *c.*365, d. Aug. 22, 408, a half-Vandal soldier, became head of the Roman army under Emperor THEODOSIUS I and effective ruler (395–408) of the western Roman Empire under Theodosius's ineffectual son, HONORIUS. Entrusted with the care of Honorius at Theodosius's death (395), Stilicho faced a series of barbarian invasions that threatened Rome itself. At Pollentia (402) he routed the Visigoths and forced them to withdraw from Italy, and at Fiesole (405) he decisively defeated the invading Ostrogoths. His attempts to annex Illyricum were less successful and served only to increase tensions between the two halves of the empire. Accused by Honorius of treason, Stilicho was executed in 408.

Still, Clyfford The American painter Clyfford Still, b. Grandin, N.Dak., Nov. 30, 1904, d. June 23, 1980, was a first-generation abstract expressionist whose mature style—a form of color-field painting—developed during the 1940s. During the 1930s, Still painted distorted figures and landscapes of the American West. In the mid-1940s his paintings became increasingly abstract, composed of dark, dry, crusty surfaces with vertical formations and jagged shapes. Still was an avowed primitive; he rejected modernist painting and was also outspokenly antitraditionalist. About 1947 his paintings expanded in scale, and during the 1950s his monumental works began to admit lighter color. Still used the image of a man standing in an open prairie as a metaphor for his work.

Still, William Grant William Grant Still, b. Woodville, Miss., May 11, 1895, d. Dec. 3, 1978, earned the title Dean of Afro-American Composers because of the successful fusion in his orchestral works of black and European musical traditions. Early in his career he gained experience as an arranger and performer (oboe, violin, cello) with dance and theater orchestras. He began composing seriously in the late 1920s, after study with George Chadwick and Edgard Varèse, and won prominence with such works as *Afro-American Symphony* (1931) and the opera *A Bayou Legend* (1940).

still-life painting Still-life painting, or the depiction of inanimate objects, such as flowers and fruits, is thought to have originated in Greek painting of the late 4th century BC. Hellenistic works almost certainly influenced Roman still-life painting, which is splendidly represented by the wall paintings and mosaics (before AD 79) found at Pompeii and Herculaneum. Later Roman artists presumably continued to make still lifes, but the art was lost in the early Middle Ages and was not to reappear as an independent art form until the 16th century.

Toward the end of the Middle Ages, artists in general began to take a new interest in the simple and direct representation of the objective world. Italian 14th-century paintings, for example, display carefully delineated furnishings and decorative contents in the background of narrative scenes. From Jan van EYCK and Rogier van der WEYDEN to Hans MEMLING and Gerard DAVID, 15th-century Flemish and Dutch artists frequently portrayed groupings of delicately painted objects as isolated still-life arrange-

Caravaggio's Basket of Fruit *(c.1596) epitomizes the realism and chiaroscuro characteristic of his work. His luminous, precisely rendered compositions engendered a tradition of still-life painting that is termed "Caravaggesque." (Pinacoteca Ambrosiana, Milan.)*

ments within their paintings. Typical of this trend is the cluster of flowers and vessels in the foreground of the nativity scene in Hugo van der GOES's *Portinari Altarpiece* (1474–76; Uffizi, Florence), in which each species of flower symbolizes a religious concept.

Independent still-life painting appeared in 14th- and 15th-century Italy as fresco or marquetry mural decorations and was further developed in both Italy and the northern European countries in the 16th century. Italian still lifes tended to emphasize arrangements of fruits and flowers, culminating in CARAVAGGIO's extraordinary *Basket of Fruit* (*c.*1596; Pinacoteca Ambrosiana, Milan). In northern painting Pieter Aertsen's *Butcher Stall* (1551; University Museum, Uppsala, Sweden) led to more conventional arrangements of foodstuffs and meals on tables, especially in work of such 17th-century Dutch masters as Jan Bruegel (see BRUEGEL family). Both Italian and Netherlandish painting influenced the evolution of a powerful still-life tradition in 17th-century Spain. Diego VELÁZQUEZ developed the *bodegón*, or kitchen painting, whereas Francisco de ZURBARÁN, Juan Sanchez Cotan, and Luis Melendez developed highly individual styles of still life.

The great master of French still life was Jean Baptiste CHARDIN, who reduced his subject matter to simple and homely elements painted with great clarity and a mastery of tone and light.

Gustave COURBET, Édouard MANET, Odilon REDON, Pierre Auguste RENOIR, and Vincent VAN GOGH produced major examples of the form in the 19th and early 20th centuries, but Paul CÉZANNE is widely acclaimed as the finest still-life painter of the modern era. His studies of fruits and vegetables set on the broad planes of tabletops influenced the Fauve and cubist painters. Following Cézanne, Henri MATISSE, Pablo PICASSO, and Georges BRAQUE made major contributions to the art of the still life in the 20th century.

(Above) Still Life with Apples and Oranges *(1895–1900) typifies the work of Cézanne in its architectural arrangement of simplified forms. (Musée d'Orsay, Paris.)* (Below) *Picasso's* Still Life with Watermelon *(1946) reflects the influence of Cézanne on 20th-century modern art. (Musée Picasso, Antibes.)*

stilt Stilt is the common name for several wading birds having moderately long necks, long bills, and long, spindly legs. The native North American species, the black-necked stilt, *Himantopus mexicanus*, is about 38 cm (15 in) long, black above and white below, with reddish legs that trail well beyond its white tail in flight. It nests in central Oregon, Colorado, Nebraska, central Florida, northern California to Mexico, the West Indies, Brazil, and Peru but may migrate far from its normal range. Stilts feed on a variety of small aquatic life and some vegetable matter. With the AVOCETS, they make up the family Recurvirostridae.

Stilwell, Joseph W. [stil'-wel] One of the most controversial American generals of World War II, Joseph Warren Stilwell, known as Vinegar Joe, b. Palatka, Fla., Mar. 19, 1883, d. Oct. 12, 1946, commanded U.S. and Chinese forces in Asia. He graduated from West Point in 1904 and, following assignments in the Far East, served with the American Expeditionary Force in France in World War I. After the war Stilwell became an instructor at West Point and served in China.

After the outbreak of World War II he became chief of staff of Generalissimo CHIANG KAI-SHEK and commander of U.S. troops in the China-Burma-India theater. His Chinese and American troops were defeated by the Japanese and driven out of Burma in 1942; with the remnants of his forces, however, he made his way through difficult terrain to India. He spent the rest of the war attempting to regain Burma (the Allies finally accomplished this in 1945). The controversy around Stilwell arose chiefly from his friction with Chiang and from his public criticisms of the Chinese leader. Relieved of his command in 1944, he commanded U.S. troops on Okinawa until the end of the war.

Stimson, Henry Lewis [stim'-suhn] The U.S. statesman Henry Lewis Stimson, b. New York City, Sept. 21, 1867, d. Oct. 20, 1950, distinguished himself as a champion of the sanctity of international agreements and as a wartime administrator. He graduated (1890) from Harvard Law School and joined a prestigious Wall Street law firm. An unsuccessful Republican candidate for governor of New York in 1910, Stimson served as secretary

Henry L. Stimson, U.S. secretary of state under Herbert Hoover, enunciated the Stimson Doctrine, a declaration that the United States would not recognize territorial changes brought about by force, in response to the Japanese occupation of Manchuria in 1931.

of war (1911–13) and as a colonel of artillery during World War I.

Stimson was governor-general (1928–29) of the Philippines and then secretary of state (1929–33) under President Herbert C. Hoover. A legalist, a moralist, and an internationalist, Stimson pressed—with limited success—for disarmament at the London Naval Conference of 1930. He opposed Japanese seizure of Manchuria, and U.S. nonrecognition of Japan's puppet regime of Manchukuo, because of its illegality, took form as the Stimson Doctrine (1931).

With the outbreak of World War II in Europe, President Franklin D. Roosevelt recruited the Republican internationalist to head the War Department for a second time (1940–45) and to organize the armed forces for war. Stimson opposed British prime minister Winston Churchill's strategy of attacking Nazi Germany through southern Europe, preferring an earlier invasion across the English Channel. He advised the president on nuclear fission, heading the committee that decided on use of the atomic bomb to end the war with Japan, but he also proposed that the United States share its nuclear knowledge with the USSR and bring nuclear fission and its development under international controls.

stimulant Stimulant drugs, or analeptics, excite the central NERVOUS SYSTEM, increasing alertness, decreasing fatigue, and delaying sleep. Some also impair appetite and may be prescribed medically to obese people in order to promote weight loss. Most users of these drugs experience a sense of well-being (euphoria), but this reaction depends greatly on the drug taken and the dose. Signs of overstimulation by these drugs, such as muscle tremors or irregular heart rate, are common.

Almost all societies have discovered some indigenous plant that produces stimulant effects. Coca leaves, for instance, are chewed by South American Indians and are the source of the drug COCAINE; khat leaves, whose active ingredient is norpseudoephedrine, are chewed by Middle Eastern peoples; betel nuts, containing arecoline, are chewed by Asians and South Pacific Islanders. Cocaine and CAFFEINE are the most familiar natural stimulants, and the AMPHETAMINES the best-known synthetic ones. The ANTIDEPRESSANTS are sometimes also classified as stimulants, as is NICOTINE, but the latter functions as both a stimulant and a depressant. Other drugs that have been used as emergency stimulants include STRYCHNINE, pentylenetetrazol, and ammonia (see SMELLING SALTS).

Caffeine. The beverages coffee, tea, cocoa, and many soft drinks contain caffeine, the most widely used stimulant drug in the world. Cocoa contains not only caffeine but also theobromine, a compound closely related to caffeine; similarly, tea contains caffeine and theophylline, a stimulant drug often used medically to alleviate asthma. Cola drinks derive their caffeine content (2 percent) from the kola nut.

Few people who drink coffee, tea, cocoa, or cola-flavored soft drinks consider themselves drug users, because these beverages are accepted socially and because the amount of caffeine is small. Furthermore, people differ greatly in their susceptibility to the stimulant effects of this drug. Over the course of an individual's lifetime, the response to caffeine may change. With increasing age caffeine users may experience for the first time insomnia or palpitations of the heart associated with irregular beats. Heavy users often become nervous, irritable, apprehensive, restless, and unable to sleep; such symptoms may be construed as a psychiatric disorder unless the history of caffeine misuse is known.

Cocaine. Once cocaine was isolated (1855), it came into medical use as a local anesthetic and as a nasal decongestant, because it shrinks mucous membranes. Its role in medicine has declined, but it has since become a major drug of abuse. Smoked, sniffed, or injected, cocaine produces a short-term sense of intense euphoria and alertness, but the drug is psychologically strongly addictive. Long-term abuse can damage the nasal septum, cause skin abscesses, and lead to psychoses. Overdoses of the drug are often fatal.

Amphetamines. Amphetamines, widely used in medical practice until recently, are sympathomimetic stimulants; that is, they act physiologically in ways similar to the sympathetic nervous system. Although synthetic, they are chemically related to ephedrine—a drug derived from Chinese shrubs of genus *Ephedra*—which is a mild stimulant used to alleviate respiratory ailments. Amphetamines are known as "pep pills" or "diet pills" because they increase energy and feelings of euphoria and decrease the desire for food.

Amphetamine (phenylisopropylamine) was first introduced into medical practice in the 1930s; it was widely used as an appetite suppressant, as a treatment for narcolepsy (uncontrollable attacks of sleepiness), and as a treatment for hyperactive children (see HYPERACTIVITY). It was also inhaled as a nasal decongestant. Other drugs with similar actions were also synthesized, including methamphetamine, methylphenidate, and pipradol. Soon after the introduction of amphetamine-related drugs in medicine, however, people discovered their euphoriant effects and began to abuse them.

Amphetamine-related drugs called anorexics or anorectics, commonly used for weight loss (see DIETING), can often be abused. Tolerance develops with chronic use; when forced to stop, the user has such withdrawal symptoms as excessive sleepiness, ravenous appetite, and mental depression.

See also: DRUG ABUSE.

stimulus-response psychology see BEHAVIORISM

stingray Stingrays are much-feared venomous fishes in the subfamily Dasyatinae, family Dasyatidae. They are flattened like other RAYS and possess broad, winglike pectoral fins, which they flap in swimming. The tail is long and whiplike and bears two strong spines at its base. The stingray usually lies partly buried in the sand. If stepped on or seized, it lashes out vigorously with its tail and attempts to drive a spine into the intruder. The spines are derivatives of the scales and are associated with poison glands; they are serrated and solid, thus cutting and tearing the flesh as well as injecting poison. The wound can be extremely painful, and the powerful poison, apparently a protein, affects the heart and the nervous system of mammals and can cause depressed respiration.

The head of the stingray is not well defined, and there is no dorsal or caudal fin. The skeleton is composed of cartilage. The gill openings are ventral, with water being taken in through paired spiracles behind the eyes. The ventral mouth has numerous small, blunt teeth. Small clams, crustaceans, and other invertebrates are caught as food when the ray digs a broad depression in the sand. The stingray is ovoviparous; the female carries eggs internally but does not nurture the fetuses, and the young are born alive. Stingrays are widely distributed in warm, shallow seas, and a few species ascend rivers in South America. They occur along the Atlantic coast of the United States as far north as Cape Hatteras. Some species may reach more than 1.5 m (5 ft) across. Stingrays may weigh from 0.7 to 340 kg (1.5 to 750 lb).

The southern stingray (seen from above) *is a broad, cartilagenous, shallow-water fish with a flattened body that grows to a width of 1.5 m (5 ft). Its tail bears poisonous spines.*

stinkbug Stinkbugs make up the family Pentatomidae in the insect order of true bugs, Hemiptera, and are characterized by their shieldlike shape and five-segmented antennae. Pentatomids are moderate in size with mottled shades of green, gray, or brown; a few are brightly colored. The common name stems from the disagreeable odor produced by glands in the thorax. Some stinkbugs are plant feeders, some predaceous, and some omnivorous. The brightly colored harlequin bug, *Murgantia histrionica*, often destroys cabbage.

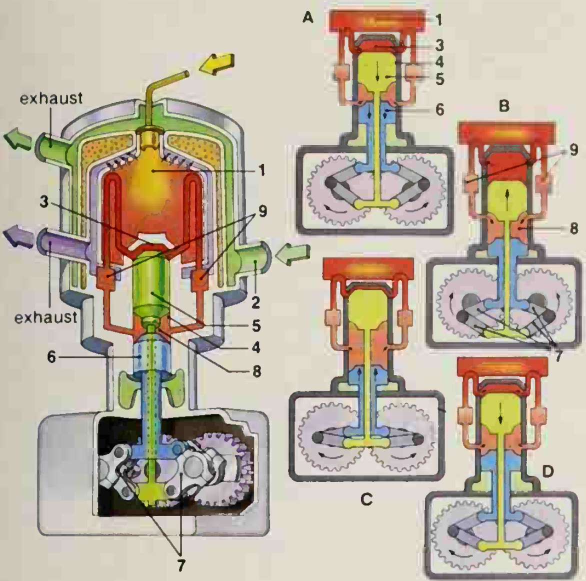
Stirling Stirling is a former county town and now the seat of Stirling district, Central region, Scotland. It has a population of 38,638 (1981). The historic site of an English defeat (1297) by the Scots under Sir William Wallace, Stirling was a favorite residence of the Stuart kings and queens of Scotland in the 14th, 15th, and 16th centuries. Its monuments include Stirling Castle, which was taken by Edward I of England after a famous siege in 1304, the Gothic Church of the Holy Rude (scene of the coronations of Mary, Queen of Scots, and her son, James VI), and the nearby ruins of Cambuskenneth Abbey. The University of Stirling was founded in 1967.

Stirling, James Frazer The Scottish architect James Frazer Stirling, b. Apr. 22, 1926, d. June 25, 1992, achieved an international reputation as an exponent of brutalism. His bold use of metal, concrete, and large areas of glass and his extensive use of prefabricated industrial components have been both praised and damned for the rigid adherence to a technocratic logic.

In partnership (1956–63) with James Gowan, Stirling completed the controversial Engineering Building (1959–63) at Leicester University, with its office tower of glass and red tile set next to a large one-story workshop roofed with prismatic glass structures. His important later buildings include the New State Gallery (1984) in Stuttgart and the Sackler Museum (1985) at Harvard.

Stirling engine The Stirling engine is a type of external-combustion engine. Invented in 1816 by a Scottish clergyman, Robert Stirling, it is now receiving serious consideration as an alternative to the internal-combustion reciprocating engine, because the Stirling emits virtually no odor and low amounts of carbon monoxide and smog-forming hydrocarbons. The Stirling engine satisfies U.S. standards for emissions of nitrogen oxides and is also significantly quieter than conventional gasoline and diesel engines. Single- and multicylinder models are made.

A single-cylinder Stirling engine has five major components: an engine heater, a regenerator, an engine cooler, a displacer piston, and a power piston. The heater is a bank of stainless-steel tubes brazed into the cylinder head and regenerator. These tubes are kept hot by burning fuel in an external combustion chamber. The regenerator is a mass of wire sealed within several cups located around the outside of the engine. The cooler consists of bundles of small tubes surrounded by an annular chamber through which cooling water is circulated. The dis-



The Stirling engine (left) *converts heat into mechanical energy through expansion of a fluid, usually hydrogen. Heat is transferred to the fluid from an external-combustion system* (1); *cooling is provided by cold-air intake pipes* (2). (A) *Working fluid in the hot end* (3) *of a cylinder* (4) *expands, forcing a displacer* (5) *and a piston* (6) *downward.* (B) *The drive linkage* (7) *moves the displacer upward, pushing fluid from the hot into the cold end* (8). *The fluid's heat is absorbed by regenerator boxes* (9). (C) *Fluid at the cold end is compressed by the piston. As its pressure and temperature rise, the fluid is cooled by passage through a cooling system. The compressed fluid regains stored heat as it flows through the regenerator boxes and returns to the hot end.* (D) *Expansion of the hot fluid pushes the displacer down again, and the cycle starts anew.*

placer piston is a hollow steel shell that fits loosely in the cylinder. The motion of the displacer piston is controlled by a piston rod connecting it to the drive mechanism in the crankcase.

stoa [stoh'-uh] In the public areas of ancient Greece, as in the AGORA, there often stood a portico—a sheltered walkway—along the walls of the more important buildings. This type of promenade, which probably evolved from an extended eave supported on posts, was called a stoa. Eventually, the stoa became quite elaborate, with interior colonnades and sometimes even a second story. Today, the most impressive of such structures is the restored Stoa of Attalus (2d century BC) in Athens. In 1981 the remains of the famous Painted Stoa, built *c.*460 BC and decorated by Polygnotus and other artists, was discovered in the Athenian Agora.

stochastic process [stuh-kas'-tik] A stochastic process is a mechanism or phenomenon that evolves randomly in time, such as the flow of traffic at a signal-controlled intersection. The characteristic feature of a stochastic process is that at each instant in time there is a RANDOM VARIABLE that describes the state of the process—for example, the number of cars waiting at the intersection. A stochastic process is defined by the collection of random variables, one for each distinct instant of time. The simplest example of a stochastic process is the random walk. This is the motion of a particle that at a sequence of times is moved one unit to the right or to the left, with probabilities that do not change. The random walk may be regarded as a simple discrete model for the motion—known as Brownian motion—of a microscopic particle bombarded by molecules in a liquid. Random walks, Brownian motion, and their generalizations find application in the social and natural sciences.

Many stochastic processes have the property that their future behavior depends only on the present state of the process and not on the past events leading up to this present behavior. Such a process is called a Markov process. Both the random walk and Brownian motion are Markov processes. A Markov process that can occupy only a discrete set of states, such as the random walk (but not Brownian motion), is called a Markov chain. The properties of a Markov chain are completely determined by its transition probabilities—the probability of moving from one state to another in a given time.

stock In finance, a stock represents a share in the ownership of an incorporated company. In industrial societies wealth used in production is owned in the aggregate mostly by CORPORATIONS rather than by individuals because of the huge investments required. This trend began in 17th-century England when merchants formed JOINT-STOCK COMPANIES, pooling capital to be used jointly in trading and manufacturing. Participants then received dividends, shares of the common PROFIT proportionate to their original investments.

Shares of widely held companies are traded on STOCK MARKETS. Stockholding is popular because it represents an ownership of capital that can be transferred easily by means of organized trading in the stock markets. There are two classes of stock: preferred and common.

Owners of preferred stock are entitled to a fixed or predetermined dividend before any common stock dividends can be paid. If profits are too low in any given period to cover all or part of a preferred dividend, the unpaid amount may be accumulated as a claim against future earnings. Preferred stock also has first claim if a company is liquidated and the proceeds divided among its shareholders.

Common stock carries with it all claims to a company's assets and earnings that have not been assigned to preferred stock or to corporate debt. Once preferred stock dividends have been met, any remaining profits are available for distribution to the common stock shareholders. Because there is no limit on the amount of dividends a common stock may receive, its market value tends to reflect assumptions made by investors as a group about the company's ability to increase earnings and thus pay higher dividends in the future.

Each owner of a corporation's common (and sometimes its preferred) stock is entitled to vote, on the basis of one vote per share held, for the company's directors, who in turn appoint its day-to-day management. If enough stockholders are dissatisfied with a company's performance, they can vote in a new management.

See also: INVESTMENT BANKING; SAVING AND INVESTMENT.

stock market Stock markets, or exchanges, are associations of brokers and dealers in securities who transact business together. They facilitate the financing of business and government activity by bringing together the buyers and sellers of STOCKS and BONDS.

A CORPORATION creates ("issues") shares of stock to represent ownership claims in the corporation. Stockholders know that the value of their stock will fluctuate with the value of the assets owned by the corporation and with the business prospects of its operations.

In virtually all instances, a corporation designs its shares of stock in a way that allows for their resale and trading. The first time that a specific share of stock is sold is when the corporation issues and sells it. This is called a primary distribution. In contrast, all subsequent trading of the same shares of stock—that is, previously issued shares—is called a secondary market transaction. This type of transaction transfers ownership from one person to another without involving the corporation that originally issued the stock.

The popular image of the stock market is that of secondary market trading. Secondary market transactions take place either through a formally organized "exchange" or through an "over-the-counter" (OTC) network of brokers and dealers. The primary sale of stock, on the other hand, is usually done through "syndicates" of INVESTMENT BANKS and retail brokerage houses that directly contact potential buyers of the new stock offering. The volume of trading of "old" shares far exceeds the initial sale of "new" shares.

In the United States the leading stock exchange is the New York Stock Exchange (NYSE). Other U.S. stock exchanges of note are the American Stock Exchange (Amex; in New York), the Pacific Exchange (Los Angeles and San Francisco), and the Philadelphia Stock Exchange. Outside of the United States the leading stock exchanges are located in Tokyo and London. As of March 1989 the market value of all shares of stock traded on the Tokyo Stock Exchange was $3.8 trillion, more than any other exchange in the world.

Operation of a Stock Exchange

An exchange decides what securities (stocks and bonds) and contracts (see OPTION TRADING and FUTURES) it wants to trade. As a first step, an exchange proposes to organize a "market" to trade a specific security or contract; with stocks, this step is the "listing" of the stock. Most exchanges will not list the stock of a company that does not meet minimum standards of operation, as set by the individual exchange. An exchange can also decide to "delist" a stock after the company has failed to meet its standards for some time. More than one exchange can list the same stock.

An exchange is a private organization. Its members—who may be either individuals or firms—are responsible for the organization and financial integrity of the markets. The main benefit of membership is direct access to the trading and support systems; all nonmembers must arrange for a member to trade on their behalf. The charter of an exchange limits the number of members, but it does allow a member to rent or sell his or her membership to someone else. Most members are either (a) brokerage houses ("broker-dealers"), who trade on behalf of their individual and institutional customers; (b) professional investors who use trading-intensive investment strategies; or (c) "market makers," who trade from their inventories in response to the flow of trading orders.

An essential feature of any exchange-sponsored market is the provision of "market-making" services. A market maker stands ready to quote a price at which he or she is willing to buy—a "bid" (price)—and a price at which he or she is willing to sell—an "ask" (price). The difference between the ask and the bid—the "bid-ask spread"—is one measure of the cost to the customer of using the market. In general, a well-functioning market is one in which orders can be executed quickly and at prices that reflect a narrow bid-ask spread.

In the over-the-counter stock markets, market makers exchange bid and ask prices through the National Association of Securities Dealers Automated Quotations (NASDAQ) system, a computer network that transmits and updates price quotations. Trading itself can occur either over the phone or through the computer linkup.

In the United States the SECURITIES AND EXCHANGE COMMISSION (SEC), an agency of the federal government, has jurisdiction over the public issuance of shares of stock and over the subsequent secondary market trading through exchanges and through the over-the-counter market. The SEC also has jurisdiction over option-contract markets for individual stocks and for stock indexes. A separate government agency, the Commodity Futures Trading Commission, has jurisdiction over futures-contract markets for stock indexes and for options on stock-index futures contracts.

Securities Transactions

The general public can use an exchange's markets by setting up an account with a brokerage that is an exchange member (or that trades through another firm that is an exchange member). A customer can provide his or her broker with a long list of instructions about when to trade and at what price, but in general, customers submit two types of orders: limit orders and market orders. A limit order tells the broker to buy (or sell) only at a price no greater (or no less) than the limit set by the customer. A market order tells the broker to execute the trade immediately at whatever price is required.

Once a trade is negotiated the buyer must still pay for the stock and the seller must deliver it to the buyer. These follow-up activities are part of the "clearing" and "settlement" procedures. Each exchange member must either be a member of a "clearing" corporation or arrange to clear transactions through a clearing member who reconciles all transactions, including trading prices and number of shares traded.

"Settlement" refers to the payment and transfer of title. Most stock transactions are settled on the fifth business day following the trade. Options and futures transactions are settled on the next business day. Clearing member firms are responsible for settling customers' trades even if the customers fail to deliver the necessary cash or securities.

Customers maintain either a cash account or a margin account with their brokers. With a cash account a customer must fully pay within seven business days; except for any balances due within seven days of a purchase, a cash-account customer can have no other outstanding obligations to his or her broker.

A margin account, however, is designed to allow customers to have outstanding obligations, as long as they maintain collateral in the account as a good-faith deposit. A customer's obligations can arise from any of three sources. He or she can borrow money from the broker (presumably to help pay for the stock purchases) or can borrow stock from the broker (presumably to sell it "short" and keep the proceeds; "selling short" is selling securities one does not own). Or the customer can write an option contract, committing him or her to buy (or sell) at a later date at prices that could be above (or below) the then prevailing market price. The exchange sets rules that specify the amount of collateral that customers with such obligations must keep in a margin account.

New Technology and the Market

Since about 1970 there have been several important developments that together have dramatically changed the nature of the stock market. First, the shift from paper-based records to electronic records has made the physical task of transferring ownership of stocks much easier, and the elimination of fixed commission rates has greatly reduced trading costs per share. Second, institutional investors (such as pension funds and insurance companies) have replaced individual investors as the dominant group in the market. Institutional investors usually hold broadly based portfolios (combined holdings of more than one security), and in response to flows of money in and out of the institutions, they prefer to trade portfolios.

In response to the institutional investors' new demands for trading, stock brokerage firms began to offer "program trading" services, which allow investors to trade a portfolio of individual stocks at once. In addition, the futures and option-contract exchanges developed new markets based on "stock indexes," which replicate the price movements of large standard portfolios. For many institutional investors, trading a stock-index contract is an effective substitute for trading the underlying stocks.

As the cost of trading stock portfolios and stock-index contracts fell, investors constructed trading-intensive strategies to control their exposure to stock-market risks (for example, "portfolio insurance") and to take advantage of temporary discrepancies between the prices in the stock market and in the stock-index contract markets ("index ARBITRAGE," for example).

In October 1987 the stock and stock-index markets experienced an unprecedented level of turmoil. Stock values dropped 30% in less than a week, and trading volumes were twice as high as they had ever been. The major group of net sellers were the portfolio insurers, who sold more than $10 billion of stocks and stock-index contracts between October 15 and October 20. The portfolio insurers concentrated their selling in the stock-index futures markets, and the index arbitragers transferred some of the selling action to the stock market by buying the futures contracts and by program-selling stock portfolios.

The events of October 1987 triggered much study and reflection about the nature of the stock markets. It heightened the public awareness of how closely the stock market is linked, through the actions of the index arbitragers, with the stock-index contract markets.

Stockhausen, Karlheinz [shtohk'-how-zen] The German composer Karlheinz Stockhausen, b. Aug. 22, 1928, has been a leader in avant-garde music since the mid-1950s. He studied at the Musikhochschule in Cologne and was a pupil (1952–54) of Olivier Messiaen in Paris. There he met Pierre Boulez and worked with the experimental composition technique known as *musique concrète*, in which tape-recorded natural sounds are manipulated through splicing, reversal, speed alteration, and other techniques. He then became music director of the Studio for Electronic Music in Cologne (see ELECTRONIC MUSIC). The study of phonetics and communication theory has further influenced his work.

His earliest music reveals traits of Bartók, Schoenberg, Stravinsky, and Webern. Webern's music pointed the way to his subsequent innovations. To Webern's theory of presenting the notes of the chromatic scale in series, Stockhausen added the serial ordering of other musical dimensions, such as volume, duration, and tone color. He expanded Webern's concept of points of interest to what he termed "group composition," in which several groups of materials, each having its own character, are linked together, sometimes leaving the order of presentation to the performer, as in *Klavierstück XI* (1956). Stockhausen's imaginative use of electronic and acoustic materials and elements of chance has produced such innovative works as *Gruppen* (1955–57), *Telemusic* (1966), *Autumn Music* (1974), and *Michael's Youth* (1978–79).

Stockholm [stahk'-hohlm] Stockholm, the capital and largest city of Sweden, lies on the country's Baltic Sea coast, about 725 km (450 mi) west of Leningrad. Located astride a navigable waterway between Lake Mälaren and the sea, the city occupies about 20 islands and several peninsulas. Its population is 672,187 (1990 est.).

Contemporary City. Stockholm has been called the "Venice of the North." Bridges and ferryboats link the various districts. Norrmalm, the financial heart of modern Stockholm, lies north of the channel, with a second business district, Södermalm, to the south. Between the two on three channel islands is the oldest part of the city, Gamla Staden (Old Town)—the site of Sweden's Royal Palace. To the west of Gamla Staden, on a peninsula jutting into Lake Mälaren, is Stockholm's City Hall. Completed in 1923 from plans by Ragnar Östberg, it is perhaps the most striking building in the city. Stockholm is famous for its many parks and open spaces.

Stockholm is now Sweden's chief manufacturing city; it is second as a port only to Göteborg. Once known for its woodworking industries, the city now produces metal and machine products, automobiles, communications equipment, paper and other wood products, and processed foods. It is the home of Sweden's principal stock exchange.

The Royal Palace, the official residence of the king of Sweden, is freely accessible to tourists. Within the palace is a famous collection of Gobelin tapestries. Nearby is the Great Church (begun 1250), the seat of Sweden's Evangelical Lutheran state church and the oldest building in the city. The University of Stockholm (1877) is the country's largest university. The Nobel Prizes are awarded annually in Stockholm, with the exception of the Nobel Peace Prize, which is presented in Oslo, Norway.

History. Stockholm is thought to have been established (*c.*1250) as a defense outpost on one of the channel islands that now make up Old Town. A member of the Hanseatic League, the city gained importance during the late Middle Ages. After the overthrow of Danish rule in 1523, Stockholm became the center of the new Swedish kingdom. Under Gustav II Adolf (r. 1611–32) Sweden became a major European power. His daughter Christina (r. 1632–54) established Stockholm as an intellectual and cultural center.

stocks (punishment) see PILLORY

Stockton Stockton, the seat of San Joaquin County in central California, lies in the fertile San Joaquin valley, about 145 km (90 mi) east of San Francisco. It has a population of 210,943 (1990). A 128-km-long (80-mi) channel, opened in the 1930s, connects Stockton with San Francisco Bay. The city is a processing and distribution center for fruits and nuts. Its industries also manufacture glass products. An art gallery, several museums, San Joaquin Delta College (1935), and the University of the Pacific (1851) are located there. Founded in 1847 as Tuleburg, the city became a service center for miners during the Gold Rush. Stockton developed after the arrival of the railroad in 1869.

Stockton, Robert Field As an American naval commander, Robert Field Stockton, b. Princeton, N.J., Aug. 20, 1795, d. Oct. 7, 1866, helped defeat enemy forces in California during the MEXICAN WAR (1846–48); later he became a U.S. senator (1851–53) from New Jersey. The son and grandson of lawyers who were prominent in New Jersey politics, Stockton served in the War of 1812 and the Algerian War (1815) against the Barbary pirates. He supported the movement for settling freed slaves in Africa and in 1821 helped the American Colonization Society negotiate a treaty securing the territory that became Liberia. Soon after the Mexican War began, Stockton became commander of the Pacific Squadron. He took command of land and sea forces, and in July and August 1846 he defeated the Mexicans in southern California, proclaimed California a U.S. territory, and established a government there.

Stoddard, Solomon [stah'-durd] Solomon Stoddard, b. Boston, Sept. 27, 1643, d. Feb. 11, 1729, was for 59 years the most influential cleric in the western half of colonial Massachusetts. Always noted for his sense of freedom from tradition, Stoddard relaxed customary restrictions on church membership in his parish. He believed that baptism and the Lord's Supper could serve as means of influencing unconverted individuals, so he offered those sacraments to all persons who sought them. Although "Stoddardeanism" was condemned by other Puritan leaders, such as the Mathers, it was widely adopted in western Massachusetts and Connecticut.

stoichiometry [stoy-kee-ahm'-uh-tree] Stoichiometry may be defined either as the measurement of the relative combining weights of the elements in chemical compounds or, more broadly, as the area of chemistry that deals with the laws of chemical combination and the weight relationships between chemical substances involved in a chemical reaction (see CHEMICAL COMBINATION, LAWS OF).

The word *stoichiometry* derives from the Greek words meaning "first principle" and "to measure." In chemistry, a stoichiometric reaction generally has no "side reactions"; that is, it yields the desired product without the occurrence of other, usually unwanted, reactions that might consume part of the reactants. The term *stoichiometric compound* refers to a single substance (not a mixture) in which two or more elements are chemically bonded together to form a compound of definite, fixed composition.

It is difficult to overemphasize the importance of stoichiometry; it is one of the cornerstones on which the science of chemistry is built. Indeed, much of the chemistry of the late 18th and 19th centuries involved the measurement of combining weight ratios of elements for the purpose of establishing a comprehensive and accurate table of atomic weights. New elements were discovered in the process, and chemistry developed as a quantitative science.

Although chemists no longer undertake quantitative chemical measurements to establish atomic weights, stoichiometry is widely used for a variety of purposes in modern chemistry. To cite but a few examples, in QUANTITATIVE CHEMICAL ANALYSIS volumetric methods are based on chemical reactions that proceed stoichiometrically so that a chemically equivalent amount of reagent has been added when the endpoint has been reached in a titration; gravimetric methods depend on a stoichiometric relationship between the sample constituent to be determined and the weight of a pure substance isolated from the sample; and in the synthesis of compounds, stoichiometry is used to calculate theoretical yields of products based on known amounts of starting materials.

Stoichiometry is also a consideration, if sometimes hidden, in a wide variety of everyday matters, such as determining how much water-softening chemical to add to obtain water of a certain softness and adjusting the carburetor of an automobile engine to achieve the optimum air-to-fuel ratio.

Stoicism [stoh'-i-sizm] Stoicism was a philosophical movement lasting about 500 years, beginning in the 3d century BC. Rational self-control and adherence to the laws of nature were fundamental aims of the Stoic school, one of the four official schools of philosophy in the Hellenistic and Roman period (the others were the Academics, the Epicureans, and the Peripatetics, who continued Aristotle's Lyceum). The Stoic school took its name from the Painted Portico (*Stoa Poikilē*) of the ancient Athenian marketplace (agora), where it first met.

The founder of this school, ZENO OF CITIUM, was influenced by the CYNICS. He proposed an austere ethical philosophy based on the individual's duty to preserve dignity and reason. Zeno taught that each human being shares in a Reason that orders the cosmos (a divine logos). Humans become good by cultivating a reasonable outlook and not giving way to emotion. The Stoic sage does not regret happenings that are outside his control, including the whole course of nature, predestined by Providence. Only the individual's own attitudes seem to be within his control.

Three main periods are recognized in the development of Stoicism. The Old Stoics held to the austere ethics of Zeno and developed an elaborate logic. Leading members of this group are Zeno, the former boxer Cleanthes, and the prolific author and logician Chrysippus. The Middle Stoics began to compromise the rigor of earlier doctrines. Although carrying on a constant fight with Epicureanism, these Stoics were scholars who adopted many ideas from the works of Plato and Aristotle, particularly in natural science and psychology. In its third, or Roman, period, Stoicism placed much more emphasis on civic duty, social responsibility, the importance of good law, and the equal basic rights of all human beings. The Roman Stoics also turned away from the detailed systematic theory of the Middle Stoics to a renewed emphasis on the earlier Stoic view of philosophy as a way of life. Roman Stoics include EPICTETUS, a slave who became a leading philosopher, Emperor MARCUS AURELIUS, the tragedian and author SENECA, and to some degree, CICERO.

Stoke-on-Trent [stohk-ahn-trent] The city of Stoke-on-Trent lies on the River Trent in northern Staffordshire, England, about 65 km (40 mi) north of Birmingham. Its population is 250,700 (1982 est.). Because of its near monopoly in England's china and earthenware manufacture, it is called the Potteries. Among the best-known trademarks are Wedgwood, Spode, Minton, Doulton, and Copeland. Other industries include coal mining and the production of rubber, steel, bricks, tiles, and chemicals. The city has a museum, an art gallery, and a technical college.

Pottery making was begun in the area in 1715 by Josiah Wedgwood. In 1910, six towns—Longton, Fenton, Stoke-upon-Trent, Hanley, Burslem, and Tunstall—united; in 1925 they became the city of Stoke-on-Trent.

Stoker, Bram [stoh'-kur] Bram Stoker, b. Dublin, Nov. 8, 1847, d. Apr. 20, 1912, created one of the most potent stories ever to haunt the imagination in the Gothic romance DRACULA (1897). Although Stoker wrote many other horror stories, such as the novel *The Jewel of Seven Stars* (1904), he and they might be forgotten were it not for the phenomenal success enjoyed by *Dracula* and the innumerable plays and films adapted from it. Exploiting traditional vampire legends and a fashion for the supernatural, Stoker's Transylvanian Count Dracula became the prototype of most later vampire tales.

Stokowski, Leopold [stuh-kahf'-skee] The conductor Leopold Stokowski, b. London, Apr. 18, 1882, d. Sept. 13, 1977, was one of the most colorful public personalities of his time. He studied at Oxford University and the Royal College of Music as well as in Paris and Munich. He arrived in the United States in 1905, and, after a few years as a church organist in New York City, he became (1909–12) conductor of the Cincinnati Symphony Orchestra, immediately attracting attention with his flamboyant conducting style. The peak of his career was reached during the next 23 years (1912–38) as he developed the PHILADELPHIA ORCHESTRA into one of the world's greatest ensembles and premiered a multitude of new works by American and European composers. At the same time, Stokowski developed a personal image of almost unprecedented glamour in the music world. He continued an active and controversial career well into his nineties. Stokowski appeared in several films, most notably in Walt Disney's *Fantasia* (1940).

STOL Short-takeoff-and-landing (STOL) aircraft encompass a class of aircraft with landing and takeoff distances considerably less than those of conventional aircraft of similar weight and size. Short-takeoff-and-landing performance is essentially achieved by reducing the landing and takeoff speeds of an aircraft.

The minimum flying speed of an aircraft is primarily determined by two factors: the ratio of the weight of the aircraft to its wing planform area, and the tendency of a wing to stall or lose lift. Stalling is a result of attempting to produce too much lift at low flight speeds. Low landing and takeoff speeds can be achieved in either of two ways: by providing the aircraft with a large wing in relation to its weight or by providing a means to augment the lift at a given flight velocity. Ways of augmenting the lift include blowing the high-velocity exhaust of the propulsion engine directly over the wing surface, thus increasing the relative velocity of the airflow over the wing and injecting high-velocity air into the airflow over the upper wing surface through slots in the wing, thereby delaying stall to a lower speed.

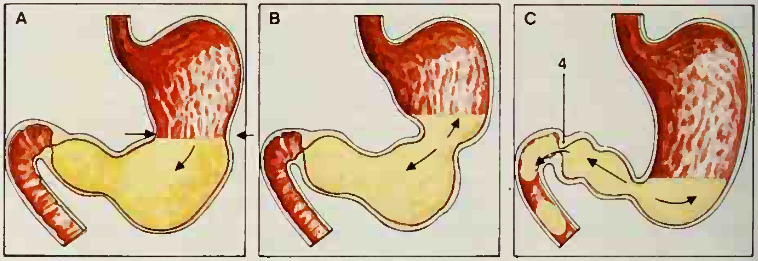
Lift augmentation appears to offer a more attractive approach for future military and commercial applications than the large-wing-area solution. The large-wing-area approach produces an aircraft that does not fly smoothly in turbulent air and has too much wing surface to obtain good cruise efficiency at speeds comparable to modern transport aircraft. Many aircraft, however, have been built that achieve STOL performance by means of a large wing area. A number of prototypes, on the other hand, have been designed with lift augmentation. Two experimental aircraft have been constructed and flown recently using the technique of blowing the jet engine exhaust directly over the wing surface.

Stolypin, Pyotr Arkadievich [stuh-lee'-pin] Pyotr Arkadievich Stolypin, b. Apr. 14 (N.S.), 1862, d. Sept. 18 (N.S.), 1911, premier (1906–11) of Russia, was the last great statesman of the Russian Empire. He was a provincial governor before becoming interior minister and chairman of the council of ministers (premier) under Emperor NICHOLAS II in 1906. He had to steer a difficult course between the reactionary bureaucracy and the left wing of the DUMA. In June 1907 he dissolved the Duma and arbitrarily promulgated new electoral laws to secure a more compliant assembly. Combining policies of force and reform, he tried to create a large class of peasant landholders. In 1911 he fell out simultaneously with the Duma, the state council, and the emperor. Soon after, he was assassinated by a police double agent.

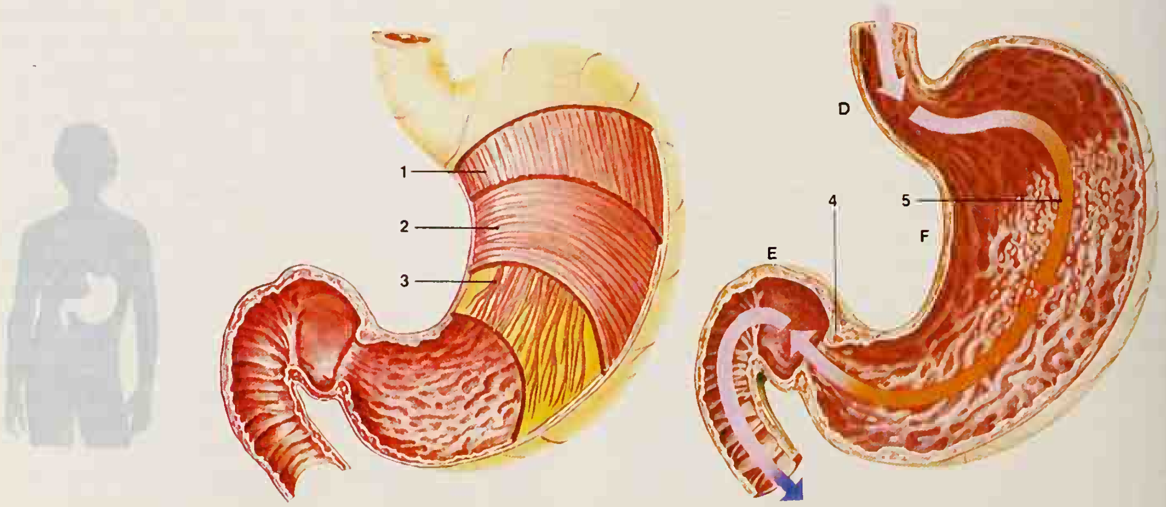
stomach The stomach is part of the DIGESTIVE SYSTEM and receives food from the esophagus. A bottle-shaped organ in humans, it is normally less than 20 cm (8 in) long and weighs about 1 percent of the body weight. It is capable, however, of distending greatly to accommodate large meals without increasing the pressure or tension on its walls. (See also DIGESTION, HUMAN.)

The stomach secretes large amounts of hydrochloric acid, which digests protein, activates pepsinogen to form the enzyme pepsin, and kills bacteria that enter the stomach. Acid is secreted from the oxyntic gland area of the gastric mucosa; other cells in this area secrete mucus and

The stomach is an expandable reservoir for food located in the abdomen. Its wall has three layers of muscle (below center): *a longitudinal outer layer* (1), *a circular middle layer* (2), *and an oblique inner layer* (3). *These muscles churn and knead solid food, helping to convert it into a semiliquid mass known as chyme.* (Right) *As the stomach fills with food, wavelike contractions of the wall begin* (A). *As the waves move along the wall* (B), *the chyme is forced out* (C) *through the pyloric sphincter* (4) *into the duodenum—the first part of the small intestine.*



Gastric juices produced by the stomach contain pepsin, a protein-digesting enzyme, and hydrochloric acid (HCl), which aids in the digestion of fibrous parts of tissues. The stomach lining also secretes mucus, which forms a barrier to protect it from the gastric juices. (Below right) *The stomach wall is dotted by glands that secrete mucus in the cardiac* (D) *and pyloric* (E) *regions. Mucus, pepsinogen—an inactive form of pepsin—and HCl, which activates the pepsin, are secreted in the fundic region* (F). *The pathway of food* (5) *indicates the area of acid activity* (orange).



the proenzyme pepsinogen. Mucus lubricates and protects the stomach wall and prevents acid from digesting the stomach itself. Pepsin is an enzyme that aids in the digestion of protein.

The mucosa of the distal third of the stomach (antrum) produces and releases the hormone gastrin into the bloodstream, which stimulates acid secretion and the growth of mucosa in the digestive tract. The sight of food and its presence within the mouth activate the vagus nerve, which directly stimulates the parietal cells to secrete acid, and the antral gastrin cells, which release gastrin into the bloodstream. The vagus nerve also stimulates pepsinogen and mucus secretion. Distention of the stomach and protein digestion products also stimulate both the parietal cells and the release of gastrin.

In abnormal conditions, the secretion of acid and pepsin is ultimately responsible for peptic ULCER disease, characterized by painful lesions in the gastric wall. Medical treatment of peptic ulcer disease is directed either at inhibiting acid secretion or at neutralizing secreted acid by the use of antacids.

stomata Stomata (singular, stoma) are microscopic openings or pores most often found in the outer, or epidermal, layer on the underside of leaves and in stems. A stoma is a space between two adjoining specialized cells called guard cells. These spaces allow an exchange of gas to take place between the atmosphere and internal tissues and also aid in the transpiration of water. Variation in turgor pressure in the guard cells resulting from external and internal conditions controls the size of the opening. When pressure is low the stoma is small, reducing loss of water. At the height of photosynthetic activity the stoma is large, allowing the free exchange of gases.

Stone, Barton Warren A frontier evangelist, Barton Warren Stone, b. near Port Tobacco, Md., Dec. 24, 1772, d. Nov. 9, 1844, was the leader of the revival at Cane Ridge, Ky., that in 1801 attracted thousands of people and continued for six or seven days and nights. Pressured by the opposition of his Presbyterian denomination to the excesses of the revival, Stone formed a new group that took the Bible as its only creed and called itself simply the Christian Church. For the most part, it joined with the like-minded followers of Alexander CAMPBELL in 1832 to become part of the DISCIPLES OF CHRIST.

Stone, Edward Durell The American architect Edward Durell Stone, b. Fayetteville, Ark., Mar. 9, 1902, d. Aug. 6, 1978, was a leading exponent of Europe's new architecture during the 1930s. In his design (1937) for the Museum of Modern Art in New York City, he gave institutional respectability to the Bauhaus-inspired International Style in the United States. Later, however, he renounced its austerity in favor of a more romantic and decorative mode. Stone's U.S. Embassy (1954–58) in New Delhi, with its templelike base and lush, fountain-filled courtyard, was hailed as an architectural marriage between East and West. Some of Stone's later projects, such as the KENNEDY CENTER FOR THE PERFORMING ARTS (1964–69) in Washington, D.C., are less successful, being overly monumental in style and scale.

Stone, Harlan Fiske Harlan Fiske Stone, b. Chesterfield, N.H., Oct. 11, 1872, d. Apr. 22, 1946, served as associate justice (1925–41) and chief justice (1941–46) of the U.S. Supreme Court. A graduate of Amherst (1894) and Columbia (LL.B., 1898), Stone taught and practiced law in New York before serving (1910–23) as dean of the Columbia Law School. Prior to appointing Stone to the Court, President Calvin Coolidge, a college friend, appointed (1924) him attorney general. In this position he reorganized the Federal Bureau of Investigation. Stone always tried to balance individual liberty and social justice, often turning away from his natural conservatism to embrace a strong position in favor of civil liberties, as in *Minersville School District* v. *Gobitis* (1940), where, as the lone dissenter, he considered saluting the flag an act of public coercion.

Stone, I. F. Isidor Feinstein Stone, b. Philadelphia, Dec. 24, 1907, d. June 18, 1989, gadfly conscience of the American political left, was the publisher of *I. F. Stone's Weekly* from 1953 to 1971. Prior to these years he wrote for a series of liberal newspapers. He wrote vigorously for an audience of activists and iconoclasts about McCarthyism and related anti-Communist campaigns, the wars in Korea and Vietnam, and the repression of blacks and other minority groups. Studying Greek after his retirement, he published *The Trial of Socrates* in 1988.

Stone, Lucy The American feminist Lucy Stone, b. West Brookfield, Mass., Aug. 13, 1818, d. Oct. 18, 1893, became one of the 19th century's leading reformers and advocates of women's rights, winning fame especially for her persuasive and moving oratory. She began her career shortly after graduating (1847) from Oberlin College in Ohio. In 1855 she married Henry Blackwell (see BLACKWELL family), though she did not adopt his name; he encouraged her efforts in behalf of abolition and women's rights. Lucy Stone was cofounder (1869) with Julia Ward Howe of the American Woman Suffrage Association; she also established its *Woman's Journal* (1870), which was published regularly for 50 years.

Stone Age see NEOLITHIC PERIOD; PALEOLITHIC PERIOD

stone alignments Ancient alignments of standing stones are found principally in western and northern Europe. They vary from a simple pair of stones, usually 2 to 5 m (7 to 16 ft) in height and separated by a few tens or hundreds of meters, to multiple arrays of 10 or more parallel rows running for a distance of more than 2 km (1.2

Stone alignments in western and northern Europe date from 3000 to 1500 BC. (Right) *The most famous alignments stand at Carnac, France, where parallel rows run for more than 2 km (1.2 mi).* (Above) *At Callanish, on the Isle of Lewis, Scotland, alignments radiate from a ring marking astronomical directions.*

mi) and containing originally more than 1,000 stones, as at CARNAC in western France. Hardly any of them has been dated by excavation or radiocarbon, but it is assumed that they are broadly contemporary with other MEGALITHS in the same areas and belong to the late Neolithic Period or the Early Bronze Age (3000–1500 BC).

In Britain and Brittany, where alignments have been studied in detail, five main types can be distinguished. In the simplest case a single standing stone, or menhir, often has a flat face that points to a prominent notch or slope on a distant skyline, marking an extreme northerly or southerly rising or setting of the Sun or Moon. In the second type the alignment is indicated either by a pair of neighboring menhirs, by the axis of symmetry of a stone ring, or by an outlying menhir seen from the center of a stone ring. In Britain there are alignments to sunrises at the equinoxes and at dates intermediate between the equinoxes and the solstices, chosen so as to divide the year into 16 "months," each of 22, 23, or 24 days. This complex annual calendar may have been used during the Early Bronze Age (2000–1500 BC).

The third type of alignment consists of straight rows of stones, usually 1 to 2 m (3.3 to 6.5 ft) high and a few meters apart, that may be single or double and run for several hundred meters. These occur mainly in Britain. The majority do not seem to have any astronomical significance; some seem to have been processional ways. Alignments of the fourth kind, consisting of multiple parallel rows of hundreds of stones, are confined to the Carnac area of southern Brittany, in France. They have been much restored, not always accurately, during the last century, so that it is now difficult to be certain of their original form. Their date and purpose are unknown, although it is generally assumed that they were built in the late Neolithic Period, from 2500 BC to 2000 BC, perhaps by the people associated with the BEAKER CULTURE. The fifth and last form of alignment consists of fan-shaped arrays of small stones, usually not more than 1 m (3 ft) in height. These are confined to northeast Scotland and Brittany. Their date and purpose are unknown, but it has been suggested that they could have served as a graphical means of calculating the precise time of the solstices or of the maximum and minimum declinations of the Moon.

Despite the traditional view that astronomy began only in the literate civilizations of Mesopotamia and Egypt at a much later date (see ASTRONOMY, HISTORY OF), the evidence provided by these stone alignments indicates a detailed knowledge of observational astronomy in prehistoric times.

See also: ARCHAEOASTRONOMY; STONEHENGE.

stone curlew Stone curlews are nine species of birds belonging to the family Burhinidae. The common stone curlew, *Burhinus oedicnemus*, is the only species that breeds in Europe. Others inhabit Australia, Asia, Africa, and tropical America.

Stone curlews are long-legged ground birds ranging from about 36 to 51 cm (14 to 20 in) in length. Their plumage is mottled and streaked in browns and grays to blend with the background. The stout bill is short to moderately long. Some species are known as thickknees because of the swollen appearance of their ankle joints. The eyes of these birds are extremely large, an adaptation to their habit of feeding nocturnally on worms, insects, and other small animals. Stone curlews nest in a depression scraped in the ground; both sexes care for the downy chicks.

stone fly Stone flies, order Plecoptera, are somewhat flattened, soft-bodied, rather dull-colored insects generally found near streams. They have four membranous wings, and the hind wings nearly always have a rounded lobe on the rear side; the wings are held flat over the body at rest. The immature stages are aquatic and usually live on the underside of stones in streams. Some stone flies emerge and mate during the fall and winter; others emerge in the summer.

Stone Mountain Stone Mountain is a gray granite mountain in De Kalb County, northwest Georgia, approximately 26 km (16 mi) east of Atlanta. This huge monadnock, which covers a 5-km^2 (2-mi^2) area, rises 198 m (650 ft) from its base and 514 m (1,686 ft) above sea level.

On the northern face of the mountain a bas-relief has been carved, depicting the equestrian figures of Confederate leaders Jefferson Davis, Robert E. Lee, and Stonewall Jackson. Gutzon Borglum, sculptor of Mount Rushmore, began the work in 1917 but discontinued it in 1925 because of a dispute with the sponsors. Augustus Lukeman worked on the project (1925–29), but it was completed by Walter Kirtland Hancock in 1968 and was dedicated in 1970.

stonecrop Stonecrop, or "live-forever plant," is the common name for the genus *Sedum*, with more than 350 species of small succulent plants, in the orpine family, Crassulaceae. They are native to the temperate and frigid zones and are thus quite hardy. Some are perennials that die to the ground in winter, and others are evergreen. Low-lying plants, stonecrops affix themselves to or grow in the crevices of rocks and walls. The flowers are usually white or yellow, with instances of pink and red. The leaves vary: opposite, alternate, and often in whorls. Most stonecrops are easily grown from seed. Propagation is also achieved through divisions, cuttings, or even a broken stem. The low-creeping evergreen *S. acre* has small leaves, less than 0.64 cm (0.25 in) long. Its yellow flowers appear in summer. *S. spectabile* is a tall stonecrop extensively used in mixed borders or as a pot plant.

Stonehenge Stonehenge, the most famous prehistoric MEGALITH (standing-stone monument) in Europe, lies 13 km (8 mi) north of Salisbury, England. Excavations and radiocarbon dating have revealed that Stonehenge had an exceptionally long history of use as a ceremonial or religious center or both. In period I (*c.*2800 BC) the site was enclosed by a circular ditch with an internal bank and an entrance on the northeast side. Inside the bank on the inner side of the ditch was a ring of 56 pits—named Aubrey holes for their 17th-century discoverer, John Aubrey—that later were used for the burial of cremated bodies. In period II (*c.*2100 BC), people of the Beaker culture built an earthwork approach road, now called the Avenue. They also set up within the earlier ring a double circle of bluestone menhirs (large, rough-hewn standing stones), which came originally from the Preseli Mountains of southwestern Wales. Both the Avenue and the double circle were orientated toward the summer solstice sunrise.

In period III (from *c.*2000 BC), builders erected in the center of the site a circle of 30 sarsen-stone uprights 30.5 m (100 ft) in diameter and capped by a continuous ring of sarsen lintels. This circle, in turn, encloses a horseshoe-shaped setting of five sarsen trilithons—formations in which two uprights support a lintel. All of the sarsen stones, which were transported about 30 km (20 mi) from the Marlborough Downs, were dressed to shape with stone hammers and jointed together. In period IV (*c.*1100 BC) the Avenue was extended to the River Avon, 2 km (1.25 mi) from Stonehenge.

Among the megalithic monuments of Europe, Stonehenge is unique because of its long period of use and the precision of its plan and its architectural details. The long-held thesis that Stonehenge was a Druid temple is untenable, because the Druids did not appear in Britain until a few hundred years before the Christian era. In recent years many attempts have been made to interpret Stonehenge as a prehistoric astronomical observatory, but the site is now so ruined, and so much restored, that any attempt to ascertain its original alignments must rely principally on guesswork. All that can be said with confidence is that from period II onward the structure's axis of symmetry pointed roughly in the direction of the sunrise at the summer solstice.

Stonehenge, Europe's best-known megalithic monument, is formed by linteled sarsens and surrounded by an earthwork. The Stonehenge circle is believed to have been a prehistoric religious center that may also have had astronomical significance.

stonemasonry Stone has been used as a structural, finish, and roofing material throughout the centuries. New materials and methods of construction developed during the 20th century, however, have almost entirely limited building stone to its use as a finish material where its decorative qualities are of value. The range of texture, color, and working qualities of building stone are almost inexhaustible.

In addition to its geological classification, building stone is further classified as cut, or dimension, stone and rubble—rough, irregularly shaped stone. Rubble walls may be composed of stones as they are collected (fieldstones) or of unfinished stone as it comes from the quarry. Rubble stones are usually set in a random pattern and are often laid without mortar (dry wall construction). Ashlar walls, in contrast, are built of cut and squared dimension stone. They may be set in regular courses, as brick is, or in broken courses where different sizes of stone are used. The characteristics and strength of ashlar masonry work depend on the properties of the stones, their size, finish, and arrangement, and the mortar joints. Mortar for stonework is usually made of white portland cement, hydrated lime, and sand. Mortar in the joints is raked back from the surface as the stones are set. The joints are later pointed, or filled, to make the finished joint.

The most common use of dimension stone is in the making of masonry veneer, where the stone is used as a finishing material.

stoneware see POTTERY AND PORCELAIN

stonewort Stonewort is the common name for a special group of multicellular plants within the algal class Charophyceae, division Chlorophyta. Stoneworts are found in brackish water, rivers, and lakes with hard water, usually attached to the bottoms. Best represented by the genus *Chara*, stoneworts are encrusted in lime deposits secreted by their cell walls, hence their name. The calcium carbonate deposits contribute to the formation of marine limestone. Highly complex, the structures of the stonewort resemble those of higher plants rather than of algae. Stoneworts are thus considered a highly developed form of green algae. They have rhizoids that resemble roots, branching stems, and whorls of branches. Stoneworts grow from stalk tips. Sexual reproduction is achieved through the fusion of one large egg from the female sex organ (oogonium) and one small sperm from the male sex organ (antheridium). Sterile cells surround the reproductive organs, a phenomenon not found in other algae.

Stoppard, Tom [stahp'-urd] An English dramatist, Tom Stoppard, b. Zlin, Czechoslovakia, July 3, 1937, moved to England with his parents as a young boy and there began a career as a reporter and free-lance journalist. His theatrical career began with the writing of radio and television plays, but his first international success came with *Rosencrantz and Guildenstern Are Dead* (1966), a retelling of the story of *Hamlet* through the eyes of courtiers, which won the 1968 Tony and New York Drama Critics Circle awards. Stoppard's inventiveness continued with such plays as *Jumpers* (1972), *Travesties* (1974), *Dirty Linen* and *New-Found-Land* (1976), *Night and Day* (1979), and *The Real Thing* (1983). He has also written a novel, *Lord Malquist and Mr. Moon* (1966). Stoppard's screenplays include that for the 1987 Steven Spielberg film *Empire of the Sun*.

stork Storks, family Ciconiidae, comprise 10 genera of 18 species of medium to large birds with long legs and beaks. They are closely related to the herons, family Ardeidae, and to the ibis and spoonbills, family Threskiornithidae. Storks are found on all continents except Antarctica but are most abundant in tropical regions. The American wood stork, *Mycteria americana*, is the only species found in the United States, breeding in Florida and neighboring states and migrating widely.

The European white stork nests on rooftops or in trees. According to European folklore the arrival of the stork signals good luck, often the birth of a baby, and its departure presages war or some other calamity.

Storks range from 76.2 to 167.6 cm (2.5 to 5.5 ft) in height. Black and white are the predominant colors, but some species have part of their plumage colored with bright pink during breeding season. The diet of storks varies greatly. Some storks favor a diet of aquatic food; some will simply catch the most available insects, frogs, fish, snakes, or rodents; and some will feed on only one type of food.

The majority of storks are colonial nesters, and most nests are built in trees and on cliffs. Others are either solitary nesters or nest in loose clusters. All species lay between three and five eggs that hatch in 32 days. Both sexes share the incubation and feeding of the young. After the young fly, they continue to return to the nest for feeding and for roosting at night for several days until they are independent. Three species of storks undertake long-range, seasonal migrations.

storm see CYCLONE AND ANTICYCLONE

Story, Joseph The youngest man ever appointed to the U.S. Supreme Court, Joseph Story, b. Marblehead, Mass., Sept. 18, 1779, d. Sept. 10, 1845, was also one of the Court's greatest legal scholars. He served from 1811 until his death and helped Chief Justice John Marshall establish the Supreme Court's power of JUDICIAL REVIEW. Story's law commentaries, including *Bailments* (1832) and *Constitution of the U.S.* (3 vols., 1833), won him widespread renown as an authority on U.S. jurisprudence.

Stoss, Veit [shtohs, fyt] Veit Stoss, 1447–1533, was one of the greatest German sculptors of the late Gothic period. In 1477, after establishing himself as a master in Nuremberg, he moved to Poland, where he carved, painted, and gilded the enormous *Altarpiece of the Virgin* (1477–89) in the Church of Saint Mary at Kraków. The reliefs and statues of this spectacular early work reveal an astounding richness of invention and great dramatic power.

After his return to Nuremberg in 1496, Stoss produced a large number of extremely moving sculptures, both reliefs and freestanding statues, in wood and in stone. Among his sculptures of extraordinary quality are the painted, wooden *Annunciation* (1517–18) suspended from the vault in the Church of Saint Lorenz in Nuremberg and the altarpiece (1520–23) now in Bamberg Cathedral.

Stout, Rex An American detective novelist, Rex Stout, b. Noblesville, Ind., Dec. 1, 1886, d. Oct. 27, 1975, created the character of Nero Wolfe, a corpulent private detective with a passion for fine food and orchids and such a thorough distaste for the modern world that he rarely left his New York brownstone. Archie Goodwin, Wolfe's legman, plays Dr. Watson to Wolfe's Sherlock Holmes, and their repartee, coupled with Stout's authoritative prose, accounts for the popularity of the series. Stout's first mystery was *Fer-de-Lance* (1934). The Nero Wolfe series includes *The League of Frightened Men* (1935), *Too Many Cooks* (1938), *If Death Ever Slept* (1957), and *The Doorbell Rang* (1965).

stove Stoves are devices that produce, contain, or direct heat for a specific purpose. When designed solely for cooking, they are often called ranges.

An open fire is relatively ineffective for heating and cooking. Humanity learned to contain fire, perhaps at first with rocks or mud and later with open braziers, which are still used today in many regions of the world.

Cast iron was used to build a stove in China about 25 to 200 AD through a process in which melted iron was poured into sand molds. Europe did not begin to use cast-iron stoves until the 1400s.

Many of the early stoves in the American colonies were jamb stoves, which were intended to make a fireplace more efficient and distribute its heat more effectively. The most common was the five-plate stove, made of five flat iron plates that formed a rectangular box with one open side. A hole was cut in the back of the fireplace completely through the wall to the room behind it, and the stove was inserted into the opening with the open end of the stove being flush against the rear wall of the fireplace. The remainder of the stove protruded into the room to be heated.

The six-plate stove originated in Holland and Scandinavia. It was enclosed on all sides and was designed to sit away from the wall. It was a relatively efficient heater.

This early Franklin-type stove was modeled on a design from the 1740s by Benjamin Franklin. Made of cast iron, the stove fitted into the fireplace, heating the room from its three sides. Although it was not suitable for cooking, the stove could keep a kettle warm.

Most early stoves were not suitable for cooking. Small, shallow pans could be placed on the top of a stove, but most of the cooking was still done in the large fireplaces of the kitchen areas. Some stoves began to serve a dual purpose when boiling holes were provided in the top. The Franklin stove, invented by Benjamin Franklin in 1742, was made of cast iron, originally with a partially open front, and was designed to fit into a fireplace. It radiated more heat and burned less fuel than an ordinary fireplace and was widely used for heating.

Wood, charcoal, and coal fueled both stoves and fireplaces. In the 1840s gas was first used for cooking, and interest grew as the availability of gas spread. The electric range was introduced in 1914. Oil and kerosene stoves have also been used for cooking in many areas.

Stowe, Harriet Beecher The author of UNCLE TOM'S CABIN (1852), an antislavery novel of such force that it is often listed among the causes of the Civil War, Harriet Elizabeth Beecher Stowe, b. Litchfield, Conn., June 14, 1811, d. July 1, 1896, also wrote the excellent depictions of rural New England life *The Minister's Wooing* (1859) and *Oldtown Folks* (1869). The daugh-

Harriet Beecher Stowe became a best-selling novelist upon the publication of Uncle Tom's Cabin *(1852), written to illustrate the evils of the fugitive-slave law. The novel focused international attention on slavery and gave added impetus to the abolitionists.*

ter of a celebrated Congregationalist minister, Lyman Beecher, Stowe moved at the age of 21 to Cincinnati, where she met and married Calvin Ellis Stowe, a biblical scholar. Her first publication, *The Mayflower; or, Sketches of Scenes and Characters among the Descendants of the Pilgrims* (1843), revealed her interest in New England personalities, but her proximity to Kentucky had also given her firsthand knowledge of the South. When she and her husband moved to Brunswick, Maine, in 1850, she drew on her recollections to write *Uncle Tom's Cabin*, followed by *The Key to Uncle Tom's Cabin* (1853) and *Dred: A Tale of the Great Dismal Swamp* (1856). After the Civil War she continued to write essays, novels, and poetry, returning to the New England scenes with which she had begun her career. By the time she died, Stowe had long been recognized at home and abroad as one of America's foremost literary celebrities.

strabismus [struh-biz'-muhs] Strabismus is a misalignment of the eyes by which they focus improperly on objects and double vision (diplopia) occurs. Cross-eye (esotropia) involves one eye looking at an object and the other turning inward. In walleyes (exotropia), the deviated eye turns outward. Children with strabismus usually subconsciously suppress the image arising from the deviating eye; eventually, this eye becomes "lazy." Temporary treatment consists of placing a patch over the other eye to force the use of the weak eye; glasses, prisms, or surgery may eventually be necessary.

Strabo [stray'-boh] Strabo, *c.*63 BC–AD *c.*21, was a Greek geographer and historian. His 17-volume *Geography* is one of the earliest books on the subject. Strabo studied under Aristodemus and Tyrannion, former teacher to Cicero. Before leaving Rome in 31 BC he completed the 47-volume *Historical Sketches*, little of which has survived.

Strabo traveled between Armenia and Sardinia and from the Black Sea to Ethiopia, incorporating both his own observations and earlier sources in the *Geography*. Strabo synthesized the geographical knowledge of the period and included descriptions of important political events and great men. The *Geography* is not uniformly useful, because Strabo took Homer too literally and refused to accept the descriptions of firsthand observers such as Herodotus.

Strachan, John [strawn] John Strachan, b. Aberdeen, Scotland, Apr. 12, 1778, d. Nov. 6, 1867, was the first Anglican bishop of Toronto (1839–67). He emigrated to Canada in 1799, was ordained (1803), and became (1813) rector of St. James' Church, Toronto. As a member of the executive (1815–36) and legislative (1820–41) councils of Upper Canada, he was a staunch defender of church interests. He became (1827) the first president of King's College (later the University of Toronto) and founded (1852) the University of Trinity College.

Strachey, Lytton [stray'-chee] A celebrated English biographer and prominent member of the BLOOMSBURY GROUP, Giles Lytton Strachey, b. Mar. 1, 1880, d. Jan. 21, 1932, established the writing of biography as a literary art. In his most famous work, *Eminent Victorians* (1918)—a reaction against the idealization of the leading figures of the Victorian age—Strachey employed a novel biographical method that illuminated the personalities of figures such as Florence Nightingale and Thomas Arnold. His literary and biographical essays, which also exhibit his perceptiveness and epigrammatic wit, appeared in *Landmarks in French Literature* (1912), *Books and Characters, French and English* (1922), and *Portraits in Miniature and Other Essays* (1931).

Stradivari (family) [strah-dee-vah'-ree] Stradivari was the name of a family of violin makers in Cremona, Italy, in the late 17th and early 18th centuries. With the AMATI and GUARNERI families, they brought violin making to its highest level. The violins of **Antonio Stradivari**, b. probably in 1644, d. Dec. 18, 1737, are considered the finest ever made. Stradivari and Andrea Guarneri learned their craft in the workshop of Nicolò Amati, whose family had been making violins for many years. Stradivari continued to work with Amati until 1684. The violins of his first period follow the Amati tradition closely.

Numerous members of the Amati and Guarneri families practiced the craft, but Stradivari was assisted by only two of his sons, **Francesco**, b. Feb. 1, 1671, d. May 11, 1743, and **Omobono**, b. Nov. 14, 1679, d. June 8, 1742.

After opening (1680) his own shop, Antonio Stradivari gradually altered his violins, increasing their size by 1690; these longer instruments with flatter arches are known as the Long Pattern. About 1700, after further experiments, his violins achieved their mature state, and the next 20 years are known as the Golden Period. Stradivari continued producing violins to the end of his life; his last instrument is dated 1737, when he was 93.

Stradivari is thought to have made approximately 1,100 instruments—mostly violins, but also some violas and cellos—of which about 700 have been traced. Almost all bear names, such as "Vieuxtemps," "Dolphin," and "Sarasate," reflecting ownership, history, or some characteristic.

Strafford, Thomas Wentworth, 1st Earl of [straf'-urd] Thomas Wentworth, 1st earl of Strafford, b. Apr. 13, 1593, d. May 12, 1641, was an English statesman and royal advisor whose execution for treason in 1641 was an early victory for Parliament in its struggle with King CHARLES I. Wentworth was elected to Parliament at the age of 21. Critical of royal policies, he was imprisoned (1627) for refusing to pay a forced loan. In 1628 he advocated presenting to Charles the Petition of Right demanding redress for grievances. After the king accepted the petition, however, and after the death of the king's favorite, the duke of Buckingham, Wentworth entered the king's service and was made viscount and lord president of the north. He was so effective that Charles appointed him lord deputy of Ireland. Arriving there in 1633, Wentworth encouraged trade, improved revenue, and handled Parliament skillfully, but he also enriched himself.

When Charles failed to suppress a Scottish rebellion, he recalled Wentworth and in 1640 created him earl of Strafford and appointed him commander in chief to fight the Scots. Strafford was unable to defeat them, however. Accused of subversion, he was impeached by the House of Commons. Strafford defended himself so brilliantly that the impeachment trial was abandoned; instead, a bill of attainder was passed and sent to the king, who signed it. Strafford was beheaded.

strain gauge The strain gauge is an electromechanical transducer that converts the strain on a structure as a result of applied force into electrical voltage. The assembly, which may be half the size of a postage stamp, is made up of a fine wire grid or foil of a metal alloy that has a high ratio of resistance change to strain. The bonded-resistance strain gauge operates on the piezoelectric effect; that is, the resistance change in the grid is directly proportional to the strain in the material to which the gauge is rigidly bonded (see PIEZOELECTRICITY).

The gauge is used in experimental stress analysis of structures and as the sensing element in some forms of load cell, torque meter, diaphragm-type pressure gauge, flowmeter, and accelerometer. Gauges have been applied to ship hulls and propeller shafts, buried in concrete dams, and bonded to aircraft to measure structural strain in flight.

Strand, Paul A major 20th-century photographer, Paul Strand, b. New York City, Oct. 16, 1890, d. Mar. 31, 1976, was known for his artistic blending of formalism and humanism. He was influenced by the Photo-Secession group and was the subject of the last two issues of Alfred Stieglitz's quarterly *Camera Work* (1917). Stimulated by modern art, Strand made abstract close-ups of bowls, machine parts, and rocks after 1915. Of his work (1922–43) in films, the documentary *The Plow That Broke the Plains* (1936) is the most celebrated. His wide travels yielded such volumes as *Time in New England* (1950), *Un Paese* (1955), and *Living Egypt* (1969).

Strang, James Jesse A follower of the Mormon prophet, Joseph SMITH, James Jesse Strang, b. Scipio, N.Y., Mar. 21, 1813, d. July 9, 1856, founded the schismatic Strangite sect after Smith's death. In 1844, Strang met Smith in Nauvoo, Ill., converted to MORMONISM, and was ordained an elder. When Smith was assassinated later that year, Strang declared himself Smith's successor, whereupon Brigham YOUNG expelled him from the church. Strang established a community of his supporters on Big Beaver Island in Lake Michigan, where he was crowned king in 1850. Twice elected to the state legislature (1852, 1854), he was shot by former Strangites and died.

Stranger, The *The Stranger* (1942; Eng. trans., 1946), Albert CAMUS's first and best-known work, takes up in novel form the philosophical question of the absurdity of modern existence. The main character, Meursault, is an alien in society who rejects bourgeois conventions without really knowing why and who lacks human feeling, as his reactions at his mother's funeral demonstrate. He nonetheless possesses a lucid awareness of the disconcerting effect he has on others. After gratuitously killing an Arab, he is condemned to death, not so much for his crime as for his nonconformity.

strangles see HORSE

Strasberg, Lee see ACTORS STUDIO

Strasbourg [strahz-boorg'] Strasbourg (German: Strassburg) is a city in northeastern France, situated about 400 km (250 mi) east of Paris and to the west of the Rhine River. The population is 248,712 (1982). The city, a strategic river port, is located on the east-west routes into France just north of the Vosges Mountains as well as on the north-south routes of the Rhine Valley. The traditional capital of the province of Alsace, Strasbourg was a German city for much of its history.

The center of the old city is on an island with branches of the Ill River on each side. Canals link the city with the Rhine, Rhône, and Marne rivers. Eastern Strasbourg is heavily industrialized. Petroleum, coal, and potash are shipped through the port. Beer, books, metal goods, machinery, and food are leading products.

Notable buildings include the Château des Rohan (18th century), a former palace, and the famous cathedral, begun in 1175 in the Romanesque style. The High Gothic style was adopted after 1235, when the nave was begun. The twin-towered west facade, begun in 1277, was finished about 1440. Constructed when Strasbourg was a German city, the cathedral is one of the most French of all German High Gothic churches. The University of Strasbourg was founded in 1538.

Strasbourg was originally a Celtic village and later a Roman fortification called Argentoratum. The Franks, who captured it in the 5th century, called it Strateburgum. In the 13th century it became a free imperial city within the Holy Roman Empire. Louis XIV of France seized Strasbourg in 1681. During the French Revolution the French national anthem, "La Marseillaise," was composed (1792) there by Claude Joseph Rouget de Lisle. After the Franco-Prussian War (1870–71), Strasbourg was ceded to Germany. The city, returned to France in 1919, was again controlled by the Germans in World War II, during which time it was damaged considerably. Strasbourg is the seat of the Council of Europe.

Strasser, Gregor [shtrah'-sur] Gregor Strasser, b. May 31, 1892, d. June 30, 1934, was, with his brother Otto (1897–1974), an early leading member of the German National Socialist (Nazi) party. A socialist before becoming a nationalist and a racist, Strasser was a leading architect of Nazism's popular base and of its electoral successes. He resigned in 1933 because of disagreements with Adolf Hitler and was murdered in the 1934 blood purge.

Strategic Air Command The Strategic Air Command (SAC), formed in 1946, is the U.S. Air Force arm that controls its long-range nuclear strike force. In the 1980s, SAC was the recipient of several new weapons systems, among them the B-1 BOMBER, the TR-1 high-altitude reconnaissance plane, and the MX MISSILE. In addition, SAC flies a fleet of modernized B-52 bombers, many of them equipped with CRUISE MISSILES or antiship missiles as well as nuclear bombs; a fleet of airborne tankers; the modernized E-4 airborne command post aircraft; and the MINUTEMAN MISSILE. SAC headquarters are at Offutt Air Force Base, Nebr.

Strategic Defense Initiative The Strategic Defense Initiative (SDI) is a U.S. research-and-development program designed to create an effective defense against nuclear-missile attack. The idea of stopping ballistic missiles en route is not new. The United States and the USSR have deployed ANTIBALLISTIC MISSILES (ABMs) in limited numbers. It is known, however, that such systems can be overwhelmed by thousands of warheads coming from many directions at once. In early 1983, in what came to be known as his "Star Wars" speech, President Ronald Reagan called for a long-term program aimed at creating a large-scale defensive system that would be primarily based in space.

As currently envisioned, the system uses a "layered" defense in which enemy missiles would come under continuous attack from the time they are launched to just before they reach their targets, a total of about 30 minutes. Surveillance satellites would register the heat given off by the rising missiles; satellite- or ground-based lasers would strike at the missiles during the boost phase, before they disgorge their many warheads. X-ray or particle-beam weapons would attack surviving missiles in space. The system could be managed only by supercomputers whose infinitely complex programs would have to be written by other computers. Most decisions would be taken out of human hands.

The costs of SDI are so huge—$100 to $200 billion—that a new, less expensive scheme was proposed in 1988. Called "Brilliant Pebbles," it would consist of several thousand space-based "interceptors," each independently guided by a powerful built-in computer and an electronic eye. The interceptor would track the heat plume of the just-fired missile and steer a collision course. New, "fast-burn" missiles could outwit the interceptors, however.

Since 1983, space tests of many experimental SDI devices have been made. Nevertheless, intensive studies by such organizations as the U.S. Office of Technology Assessment (OTA) and the Federation of American Scientists (FAS) are pessimistic about the possibility of developing reliable SDI weapons.

Because its signatories thought that maintaining their mutual vulnerability was the most effective way to avoid war, the Anti-Ballistic Missile Treaty of 1972 severely limits its ballistic-missile defense (see ARMS CONTROL). If deployed, the SDI would abrogate that treaty, and others, with consequences that have been bitterly debated. The FAS believes that even testing may violate the ABM treaty.

strategy and tactics, military Military strategy and tactics are essential to the conduct of warfare. Broadly stated, strategy is the planning, coordination, and general direction of military operations to meet overall political and military objectives. Tactics implement strategy by short-term decisions on the movement of troops and employment of weapons on the field of battle. The great military theorist Carl von CLAUSEWITZ put it another way: "Tactics is the art of using troops in battle; strategy is the art of using battles to win the war." Strategy and tactics, however, have been viewed differently in almost every era of history. The change in the meaning of these terms over time has been basically one of scope as the nature of war and society has changed and as technology has changed. Strategy, for example, literally means "the art of the general" (from the Greek *strategos*) and originally signified the purely military planning of a campaign. Thus until the 17th and 18th centuries strategy included to varying degrees such problems as FORTIFICATION, maneuver, and supply. In the 19th and 20th centuries, however, with the rise of mass ideologies, vast conscript armies, global alliances, and rapid technological change, military strategy became difficult to distinguish from "grand strategy," that is, the proper planning and utilization of the entire resources of a society—military, technological, economic, and political. The change in the scope and meaning of tactics over time has been largely due to enormous changes in technology. Tactics have always been difficult—and have become increasingly difficult—to distinguish in reality from strategy because the two are so interdependent. (Indeed, in the 20th century, tactics have been termed *operational strategy*.) Strategy is limited by what tactics are possible; given the size, training, and morale of forces, type and number of weapons available, terrain, weather, and quality and location of enemy forces, the tactics to be used are dependent on strategic considerations.

Strategic and Tactical Principles of Warfare

Military commanders and theorists throughout history have formulated what they considered to be the most important strategic and tactical principles of war. Napoleon I, for example, had 115 such principles. The Confederate general Nathan Bedford Forrest had one: "Get there first with the most men." Some of the most commonly cited principles are the objective, the offensive, surprise, security, unity of command, economy of force, mass, and maneuver. Most are interdependent.

Military forces, whether large-scale or small-scale, must have a clear objective that is followed despite possible distractions. Only offensive operations—seizing and exploiting the initiative—however, will allow the choice of objectives; the offense also greatly increases the possibility of surprise (stealth and deception) and security (protection against being surprised or losing the possibility of surprising the enemy). Unity of command, or cooperation, is essential to the pursuit of objectives, the ability to use all forces effectively (economy of force), and the concentration of superior force at a critical point (mass). Maneuver consists of the various ways in which troops can be deployed and moved to obtain offensive, mass, and surprise. A famous example that illustrates most of these principles occurred during World War II when the Allied forces eventually agreed on the objective of defeating Germany first with a direct offensive against the European continent. Under a combined command headed by Gen. Dwight D. Eisenhower, they effectively massed their forces in England, deceived Germany regarding the point of invasion, collected intelligence on the disposition of German forces, and set the vast maneuver called Operation Overlord into motion.

Unthinking rigid attention to a principle of war, however, can be unfortunate. In the face of two Japanese naval forces, Adm. William Halsey's decision at Leyte Gulf not to divide the fleet (the principle of mass) led to the pitting of the entire enormous American naval force against a decoy Japanese fleet. Division of the fleet (maneuver) would still have left Halsey superior to both Japanese forces.

Classification of actual military types of maneuvers and their variations have long been a part of military science. New technology and weapons have not drastically altered some of the classical types of offensive maneuver: penetration, envelopment, defensive-offensive maneuvers, and turning movements.

The Historical and Theoretical Development of Strategy and Tactics

The historical roots of strategy and tactics date back to the origins of human warfare and the development of large-scale government and empire. The dense tactical infantry formation of overlapping shields called the phalanx, for example, existed in an early form in ancient Sumar (*c.*3000 BC). The development of strategy and tactics parallels to some extent the growth, spread, and clash of civilizations; technological discoveries and refinements; and the evolution of modern state power, ideology, and nationalism.

Early Strategy and Tactics. The Mediterranean basin saw the dawn of modern military strategy and tactics. It was under such leaders as Philip II (382–336 BC) and Alexander the Great (356–323 BC) of Macedonia and Hannibal (247–183 BC) of Carthage that the first great strides were made in military science. Philip combined INFANTRY, CAVALRY, and primitive ARTILLERY into a trained, organized, and maneuverable fighting force backed up by engineers and a rudimentary signaling system. His son Alexander became an accomplished strategist and tactician with his concern for planning, keeping open lines of communication and supply, security, relentless pursuit of foes, and the use of surprise. Hannibal was a supreme tactician whose crushing victories taught the Romans that the flexible attack tactics of their legions needed to be supplemented by unity of command and an improved cavalry. The Romans eventually replaced their citizen-soldiers with a paid professional army whose training, equipment, skill at fortification, road building, and siege warfare became legendary. The Byzantine emperors studied Roman strategy and tactics and wrote some of the first essays on the subject.

The Middle Ages saw a decline in the study and application of strategy—with the exception of the great Mongol conqueror Genghis Khan. Medieval tactics began with an emphasis on defensive fortifications, siegecraft, and armored cavalry. The introduction, however, of such new developments as the crossbow, longbow, halberd, pike, and, above all, GUNPOWDER began to revolutionize the conduct of war.

The Emergence of Modern Warfare. Gustav II Adolf, king of Sweden (r. 1611–32), has been called the father of modern tactics because he reintroduced maneuver into military science. His disciplined national standing army—differing from the common use of mercenaries—was organized into small, mobile units armed with highly superior, maneuverable firepower and supplemented by mounted dragoons (his creation) armed with carbine and saber. Frederick II (the Great) of Prussia (r. 1740–86), the master of initiative and mass, conducted war in an age of limited warfare—armies were small and expensive; road and supply systems were inadequate.

With Napoleon I, however, the age of modern warfare was born (see NAPOLEONIC WARS). The French Revolution (see FRENCH REVOLUTIONARY WARS) had produced a mass patriot army organized into loose divisional formations. Napoleon carefully planned his campaigns and quickly maneuvered his troops by forced marches to a selected field of battle. His battles began with skirmishing and cannonading, followed by an overwhelming concentration of forces in shock BAYONET attacks against enemy flanks in turning and enveloping movements designed to utterly destroy opposing forces. Because of the greater complexities of warfare, a rudimentary GENERAL STAFF began to emerge under Napoleon.

The Nineteenth Century: Theory and Technological Change. Napoleonic strategy and tactics were closely studied by the first great theorists of war, the Prussian general Carl von Clausewitz (1780–1831) and the French general Antoine Jomini (1779–1869). Clausewitz's *On War* (1832–34; Eng. trans., 1908) emphasized the close relationship between war and national policy and the importance of the principles of mass, economy of force, and the destruction of enemy forces. Jomini, on the other hand, emphasized occupying enemy territory through carefully planned, rapid, and precise geometric maneuvers. Whereas Jomini's theories had influence in France and North America, Clausewitz's teachings in particular were influential on the great Prussian military strategists of the 19th century, Helmuth von MOLTKE—architect of victory in the Franco-Prussian War (1870)—and Alfred von SCHLIEFFEN—creator of the

Schlieffen plan (defense against Russia and envelopment of France), which Germany applied in a modified form at the beginning of World War I.

The 19th century was an era of far-reaching technological change that vastly altered the scope of tactics and strategy, an alteration seen in what has been called the first total war, the U.S. CIVIL WAR. Railroads and steamships increased the volume, reach, and speed of mobilization and of CONSCRIPTION. The consistent support of war industry became critical. The growth in range and accuracy of rifle firepower (see FIREARMS) created new tactical problems: artillery had to be placed further behind the lines, massed charges became ineffective if not disastrous (see GETTYSBURG, BATTLE OF), cavalry became limited to reconnaissance and skirmish, and troops began to fight from trenches and use GRENADES and land MINES. Telegraph communications linked widening theaters of war and made large-scale strategy and tactics possible. During the U.S. Civil War the large-scale strategy of the North (BLOCKADE, division of the Confederacy, destruction of the Confederate armies and supplies) backed by superior industry and manpower were the key factors in its victory. The development of the MACHINE GUN late in the 19th century would have its most telling effect in World War I.

World Wars: Trench Tactics to Nuclear Strategy. World War I began with immense, rapid, national mobilizations and classical offensive maneuvers, but after mutual attempts at envelopment at and after the Battle of the Marne, stationary trench warfare ensued across a wide battlefront. A war of attrition set in that called for total national involvement in the war effort. Two key technological developments in the war were to fashion the strategic and tactical debates of the 1920s and 1930s. The use of airpower (see AIR FORCE; AIRCRAFT, MILITARY) was advocated by such theorists as Giulio Douhet (1869–1930), Billy MITCHELL, Henry ("Hap") ARNOLD, and Hugh Trenchard (1873–1956). They insisted that air power alone could win wars, not only by striking at enemy forces but by strategic bombing—the massive attack on cities, industries, and lines of communication and supply that characterized part of allied strategy during World War II. The other World War I development was that of motorized ARMORED VEHICLES such as the tank. The use of the tank as the new cavalry of the modern age was advocated by B. H. Liddell Hart (1895–1970), Charles de Gaulle (1890–1970), and J. F. C. Fuller (1878–1966) in the interwar period. The Germans were the first to effectively use the tactical offensive combination of air and tank power in the field of battle in the BLITZKRIEGS, under such commanders as Heinz Guderian and Erwin Rommel, which conquered much of Europe in World War II.

The primary tactical advance in World War II may have been that of AMPHIBIOUS WARFARE. The principal significance of that war, however, was in the first application of truly global strategies wielded by massive coalitions dedicated once again to the offensive. The development of nuclear weapons, which continued after the war, introduced the new science of NUCLEAR STRATEGY and tactics. The immensely destructive nature of these weapons, however, meant that warfare of limited strategic goals, using conventional but constantly refined weapons and conventional (and sometimes unconventional; see GUERRILLA) tactics, would predominate in the years after World War II.

See also: ARAB-ISRAELI WARS; NAVAL VESSELS; NAVY; STRATEGIC DEFENSE INITIATIVE.

Stratford-on-Avon Stratford-on-Avon in southern Warwickshire, England, lies on the River Avon, about 145 km (90 mi) northwest of London. The population is 20,800 (1982 est.). The borough's industries include brewing, canning, and metalworking. A weekly market has been held since 1196. The birthplace of William Shakespeare, Stratford-on-Avon derives most of its income from tourism. Visitors see Shakespeare's birthplace, the site of his retirement home, his tomb, and the houses once occupied by his daughter and his wife, Anne Hathaway. Other notable landmarks are a 15th-century bridge, the Royal Shakespeare Theatre (rebuilt 1932), the Swan Theatre (opened 1986), and several museums.

A Roman ford on the site was the nucleus of an Anglo-Saxon village first mentioned in 699. Annual Shakespearean festivals have taken place there since 1879.

Strathclyde [strath'-klyd] Strathclyde is an administrative region in western Scotland with an area of 13,773 km^2 (5,318 mi^2) and a population of 2,316,700 (1988 est.)—almost half the total population of Scotland. GLASGOW is the major city. Economic activities include shipbuilding, light and heavy engineering, banking, insurance, and communications. Strathclyde was also the name of an independent Celtic kingdom that existed in the area from the 5th to the 10th century. The region was created during the 1975 reorganization of local government from the former counties of ARGYLL, AYR, DUNBARTON, LANARK, RENFREW, and Bute.

Strathcona and Mount Royal, Donald Alexander Smith, 1st Baron [strath-koh'-nuh] Donald Alexander Smith, 1st Baron Strathcona and Mount Royal, b. Scotland, Aug. 6, 1820, d. Jan. 21, 1914, was a Canadian fur trader, railway entrepreneur, and politician. He joined the HUDSON'S BAY COMPANY in 1838, ultimately becoming its governor in 1889. Smith was negotiator for the Canadian government in the 1869 Red River Rebellion and subsequently a Conservative representative in the Manitoba legislature (1870–74) and in the federal House of Commons (1871–80). After 1873, Smith became a promoter of the St. Paul, Minneapolis and Manitoba Railway. In 1880 he reinvested his profits in the much larger Canadian Pacific Railway, which owed much of its success to his steady backing. Smith served again in Commons (1887–96) and was also president (1887–1905) of the Bank of Montreal. He was created baron in 1897 and served as Canadian high commissioner to Great Britain from 1896 to his death.

stratigraphy Stratigraphy is the branch of geology that deals with the classification and subdivision of stratified rocks. The vast majority of stratified rocks are sedimentary, but igneous and metamorphic rocks sometimes exhibit a kind of stratification as well. The term *stratum* is derived from the Latin verb *sternere*, "to spread," and this implies a planar unit, or a blanket of rock distributed over a large area.

Development of stratigraphy during the 20th century has been coupled to the development of the petroleum industry. Understanding the origin and distribution of sedimentary rocks is a prerequisite for locating oil and gas concentrations. Recognizing this, various petroleum companies have supported the work of making detailed geologic maps of remote areas of the world. They also have organized large research programs directed toward an understanding of the origin of particular rock types, such as reef limestones.

The goals of stratigraphy change with the general advance of science. For example, marine geologists and climatologists are currently studying fossil content and isotopic composition of deep-sea sediment cores to determine ocean temperatures and salinities during the past few million years. From these interpretations they can infer past changes in climate and better predict long-range changes for the future.

Stratigraphic Units

Stratigraphy is mostly a qualitative science based on types. It became obvious that increasing confusion was resulting from inconsistencies in descriptions: various geologists had developed their own terminologies and were disregarding the terminologies of others.

In order to rectify this situation, the American Commission on Stratigraphic Nomenclature defined (1961) a Code of Stratigraphic Nomenclature. Four major categories of stratigraphic units are defined: rock-stratigraphic units, distinguished on the basis of lithologic characteristics (bed, member, formation, group, supergroup); biostratigraphic units, characterized by fossils contemporaneous with deposition (zone, subzone, zonule); time-stratigraphic units, which are subdivisions of rocks considered solely as the record of a specific interval of time (system, series, stage); and geologic-time units, which are divisions of time distinguished by the rock record (era, period, epoch, age).

The fundamental rock-stratigraphic unit is the formation. Individual formations are referred to by a geographic prefix, the name being chosen for a natural or artificial feature at or near which the rock-stratigraphic unit is typically developed. Tradition has given rise to a profusion of names and has introduced complex problems of correlation.

Stratigraphic Correlation

Correlation is, in fact, one of the most important aspects of stratigraphy. In its more general sense the term means a demonstration of temporal, lithologic, or paleontological similarity between units that occur in two or more different areas. As used by many stratigraphers, however, the term is restricted to description of geographically separated stratigraphic units that were formed at equivalent times.

Temporal correlation of units geographically separated by short distances can be accomplished by noting lithologic similarities. Particularly useful are thin strata of unusual composition that were deposited quickly over a large area. A good example is a bed of volcanic ash. Correlation of units separated by large distances usually depends on identification of similar fossils. This technique must be employed with caution, however, because the fossil occurrence of most organisms is ecologically controlled. In addition, the migration of a particular species may take substantial time. For these reasons, biostratigraphic units do not necessarily have boundaries parallel to time-stratigraphic units; that is, two rocks of different age may have similar fossil content. As the segment of time involved becomes greater, the reliability of the correlation also tends to become greater.

The use of fossils permits the establishment of only a relative order of events. Absolute ages of deposition for sedimentary units are determined by RADIOMETRIC AGE-DATING. This technique, as conventionally employed, measures the age of crystallization of a mineral in which are incorporated small amounts of a radioactive element. As the element decays, the decay products are trapped in the mineral. The ratio of radioactive element to decay product indicates the length of time since crystallization.

This technique is ideally suited to dating igneous and metamorphic rocks, in which minerals have crystallized under near-equilibrium conditions of high temperatures. Sedimentary depositional ages are much more difficult to measure, because little recrystallization takes place, and what does is generally under unspecified conditions. Limited success has been achieved in dating sediments by their authigenic clay content. Fossils have been dated by the isotopic content of their skeletons. The most reliable stratigraphic dates, however, are those established by measuring the ages of adjacent igneous or metamorphic rocks.

stratosphere The stratosphere is the second lowest of the four atmospheric layers. Its lower boundary is called the TROPOPAUSE; its upper boundary, the stratopause. The underlying troposphere is characterized by a vertical temperature gradient and thus vertical instability (weather changes). In contrast, temperatures in the stratosphere remain the same or even increase with increasing height, which indicates vertical stability. The stratospheric air flow is mainly horizontal. Ultraviolet absorption by ozone (see OZONE LAYER) causes the high temperatures of the stratopause, which is usually between 48 and 53 km (30 and 33 mi) above the Earth's surface.

stratus clouds Stratus clouds are layered, gray clouds with rather uniform bases and tops. They are usually composed of water droplets, although ice crystals are occasionally present. Usually of limited vertical extent, they generally do not produce precipitation; drizzle or snow grains fall when they do. Fog results when the bases of stratus clouds descend to the ground. Stratus clouds

A dense, dark bank of stratus clouds hangs low over Long Island (N.Y.) Sound. Above the stratus clouds a formation of stratocumulus clouds disperses after a storm.

commonly occur when warm, moist air moves over cold ground surfaces during winter, or over cold ocean water during any season. Development of stratus clouds is extremely common over the cold seawater off the northwestern U.S. coast.

Closely related to stratus clouds are the stratocumulus clouds; the latter, however, have undulating bases and are capped by cauliflower tops, whereas stratus clouds are uniformly diffuse. Nimbostratus clouds, as opposed to stratus, have a denser and wetter appearance and produce larger-sized raindrops and snowflakes. Layered, or stratiform, clouds that occur in the middle and upper troposphere are labeled altostratus and cirrostratus, respectively.

Strauss (family) [shtrows] Through much of the 19th century, Viennese dance music was dominated by Johann Strauss, Sr., and his sons.

Johann Strauss, Sr., b. Mar. 14, 1804, d. Sept. 25, 1849, the son of a Viennese innkeeper, became a violinist, and in 1823 he joined the ensemble of Josef Lanner, a composer of dance music. The two young men were the creators of the Viennese WALTZ. Lanner's ensemble grew in size and popularity and eventually divided into two orchestras, one of which Strauss conducted. In 1825, Strauss left Lanner to form his own orchestra, which quickly became the favorite of the Viennese public largely through the lively conducting of its founder. Strauss composed 152 waltzes, about 100 compositions in other dance forms, and marches, but his best-known piece is the "Radetzky March."

Johann Strauss, Jr., immortalized the Viennese waltz with such compositions as "The Beautiful Blue Danube" (1867) and "Tales of the Vienna Woods" (1868). In addition to dance music, he composed such popular operettas as Die Fledermaus *(1874) and* The Gypsy Baron *(1885).*

Johann Strauss, Jr., b. Oct. 25, 1825, d. June 3, 1899, became a musician against his father's wishes. After studying the violin in secret with the encouragement of his mother, he then began the serious study of composition. At the age of 19 he formed his own orchestra, playing in the cafés of Vienna, and soon eclipsed his father in popularity. Upon his father's death in 1849, both orchestras were merged under his direction. With that group he toured widely, visiting Russia in 1865, England in 1869, and the United States in 1876. Everywhere he and his music were greeted with great enthusiasm. In all, Strauss composed about 170 waltzes—the most beloved being "The Beautiful Blue Danube" (1867), "Artists' Life" (1867), "Tales of the Vienna Woods" (1868), "Wine, Women, and Song" (1869), "Roses from the South" (1880), and "The Emperor Waltz" (1888)—and many polkas, quadrilles, and marches, totaling about 500 works. Of his 16 operettas, *Die Fledermaus* (The Bat, 1874) and *Der Zigeunerbaron* (The Gypsy Baron, 1885) were the most successful.

Neither of the other sons had a career as brilliant as the younger Johann's. **Josef Strauss**, b. Aug. 22, 1827, d. July 21, 1870, composed 283 dances and occasionally conducted the family orchestra. **Eduard Strauss**, b. Mar. 15, 1835, d. Dec. 28, 1916, published 318 compositions and also took over conducting chores from his oldest brother. Eventually, as Johann wanted more time to compose, Eduard took full charge of the orchestra, maintaining it until 1902.

Strauss, Franz Josef A powerful political figure in West Germany for more than three decades, Franz Josef Strauss, b. Sept. 6, 1915, d. Oct. 3, 1988, was chairman of the Christian Social Union, the Bavarian wing of West Germany's Christian Democratic party, from 1961 until his death. Elected (1949) to the Bundestag, he was defense minister from 1956 until he was forced to resign in 1962. He was finance minister from 1966 to 1969 and ran unsuccessfully for the chancellorship in 1980. A strong anti-Communist and NATO supporter, he nevertheless became active in promoting East-West trade. As premier of Bavaria (1978–88), Strauss was credited with making that state the most prosperous in West Germany.

Strauss, Richard The eminent German composer-conductor Richard Strauss, b. Munich, June 11, 1864,

The last composer of the romantic tradition was the German Richard Strauss. The inspiration of his program music, such as Thus Spake Zarathustra *(1896), was often literary, and* Der Rosenkavalier *(1911) was one of his operas set to librettos by the Austrian poet Hugo von Hofmannsthal.*

d. Sept. 8, 1949, is best known for his operas and tone poems. His father was Franz Strauss, Germany's leading horn player. Young Strauss made his conducting debut without rehearsal in Munich in 1884, which led to his appointment as Hans von Bülow's assistant, then successor, with the Meiningen Court Orchestra.

Conducting appointments at Munich, Bayreuth, and Weimar enabled him to astonish the world with the performance of his tone poem *Don Juan* (1888). His first (thoroughly Wagnerian) opera, *Guntram*, was performed at Weimar in 1894. That autumn he became court conductor of the Munich Opera. Among his most popular works are the tone poems *Till Eulenspiegel* (1895), *Thus Spake Zarathustra* (1896), *Don Quixote* (1897), and *A Hero's Life* (1898).

From 1900, Strauss concentrated on operas. The cynical *Feuersnot* of 1901 was followed by the more advanced *Salome* (1905) and the powerful *Elektra* (1909). The crowning glory, *Der Rosenkavalier* (1911), brought fortunes to both Strauss and his librettist, the Austrian poet Hugo von Hofmannsthal. *Ariadne auf Naxos* (1912) followed.

After losing his fortune, invested in London, Strauss composed the superficial *Alpine Symphony* (1915) and the complex, though beautiful, *Frau ohne Schatten* (Woman without a Shadow, 1919). He founded the Salzburg Festivals in 1917 with Hofmannsthal and Max Reinhardt, then became codirector of the Vienna Opera.

Strauss wrote an autobiographical libretto for *Intermezzo* (1924), but the partnership with Hofmannsthal resumed with *Die aegyptische Helena* (The Egyptian Helen, 1928) and *Arabella*, completed by Hofmannsthal just before he suddenly died, in 1929. Strauss then set *Die schweigsame Frau* (The Silent Woman) to a libretto by Stefan Zweig, banned (1935) by the Nazis after two performances because Zweig was Jewish. Strauss was expelled as head of the Reichsmusikkammer, and his music was banned for a year. Because his daughter-in-law and grandsons were of Jewish ancestry, he was forced to make a deal with the Nazis for their protection. After the war, Strauss was politically rehabilitated in London with a festival organized by Sir Thomas Beecham. His later compositions mark a return to inspiration and sweetness: the opera *Capriccio* (1942), the threnody for strings *Metamorphosen* (1945), the Oboe Concerto (1945), and *Four Last Songs* (1948).

Stravinsky, Igor [struh-vin'-skee] Igor Fedorovich Stravinsky, b. Oranienbaum, near Saint Petersburg, Russia, June 17 (N.S.) 1882, d. New York City, Apr. 6, 1971, was one of the greatest composers of the 20th century. The son of a famous bass singer at the Imperial Opera, Stravinsky showed little inclination to pursue a musical career until, while a law student, he began to study composition with Nikolai Rimsky-Korsakov. Stravinsky was catapulted into the musical limelight with the composition of three ballets for the Ballets Russes de Serge Diaghilev in Paris: *Firebird* (1910), *Petrushka* (1911), and *The Rite of Spring* (1913). The latter work caused a celebrated scandal at its first performance and remains one of the best-known and most influential pieces of 20th-century music. During World War I, Stravinsky lived in Switzerland, and shortly afterward he settled in France. His creative association with Diaghilev continued until 1929 and included notable collaborations with Pablo Picasso and Leonid Massine (*Pulcinella*, 1920), Jean Cocteau (*Oedipus Rex*, 1927), and George Balanchine (*Apollon Musagète*, 1928). In 1939 he moved to the United States.

The shimmering orchestral effects of *Firebird*; the novel, bitonal "Petrushka" chord (combining C major and F-sharp major simultaneously); and the syncopated and irregular rhythms of both ballets—all paved the way for the harsh polytonal dissonances and the violent and percussive rhythmic techniques of *The Rite of Spring*. The use of repetitive folklike melodic motives, mixed meters, polyrhythms, and ostinatos are all characteristic, and most of these techniques remained distinguishing traits of Stravinsky's style. Out of practical necessity, Stravinsky pared down the enormous performing resources of *The Rite* to more economical proportions in works such as *L'Histoire du Soldat* (1918), scored for seven instrumentalists. The influence of jazz is reflected in *Ragtime* (1918) and *Ebony Concerto* (1945).

A revived interest in the music of the past, particularly in that of the baroque and classical periods, as well as Stravinsky's aesthetic predilection for clarity and balance, led to the composition of a number of neoclassical works, including the Octet for Wind Instruments (1923), the Concerto for Piano and Winds (1924), the Piano Sonata (1924), and *Dumbarton Oaks* Concerto (1938). Profound religious feeling was expressed in works such as the *Symphony of Psalms* (1930) and Mass (1948). Stravinsky continued to compose ballets and collaborated with Balanchine on *Jeu de cartes* (1936), *Orpheus* (1947), and *Agon* (1957). His only full-length opera, *The Rake's Progress* (1951), com-

The 20th-century composer Igor Stravinsky was born in Russia but later emigrated to France and the United States. He achieved success with Firebird, *a ballet performed in Paris in 1910, but* The Rite of Spring, *although now revered as a classic, met with scorn.*

posed to a libretto by W. H. Auden and Chester Kallman, startled the musical world with its eclectic use of elements derived from Wolfgang Amadeus Mozart and Italian opera. Even more controversial was Stravinsky's turn to serialism, inspired by Anton von Webern, in works dating from the mid-1950s. The use of serial technique in such compositions as *Threni* (1958), *Elegy for J. F. K.* (1964), and *Requiem Canticles* (1966) resulted in concise, highly structured works.

strawberry Strawberries are low-growing perennial plants, genus *Fragaria* of the rose family, Rosaceae, that are cultivated for their juicy red fruits. Wild strawberry plants, bearing tiny fruits, are native to temperate regions and have been picked for food since antiquity. Cultivation of the strawberry as a garden plant began in 13th-century France. Two native American species, *F. chiloensis* and *F. virginiana*, were introduced into Europe, and their hybridization produced the many modern varieties of large, cultivated strawberries. Strawberries are now grown in almost every part of the temperate world, and new varieties have been developed to meet differing geographical and climatic conditions. The strawberry is almost always propagated by cutting off and replanting the many long runners produced by the plant. A few species—notably the European Alpine strawberry, *F. vesca*—do not put out runners and are propagated by division or through seed. Most plants flower in the spring and develop fruits in about 5 weeks. Some strawberry varieties, however, are "everbearing": they produce both a spring and a late-summer or fall crop.

stream see RIVER AND STREAM

stream of consciousness A term coined by William James in 1890, *stream of consciousness* is used to refer to a technique by which modern writers render the flow of their characters' thoughts. By recording a character's half-formed perceptions, shifting perspectives, and seemingly illogical associations, the novelist enables the reader to get inside a character's mind. The term is sometimes used synonymously with *interior monologue*. The possibilities of the technique were first fully demonstrated by James JOYCE, but he had a number of precursors, notably Laurence Sterne, whose TRISTRAM SHANDY (1760–67) is full of false starts, apparent irrelevancies, and digressions of every kind. Joyce's ULYSSES (1922), Virginia Woolf's *Mrs. Dalloway* (1925) and *The Waves* (1931), and William Faulkner's The SOUND AND THE FURY (1929) are all examples of the technique.

Streep, Meryl The actress Mary Louise "Meryl" Streep, b. Summit, N.J., June 22, 1949, has won critical praise on stage, screen, and television. Streep was acclaimed for her Broadway performance in Tennessee Williams's *27 Wagons Full of Cotton* (1976). Among her television credits is the miniseries "Holocaust" (1978; Emmy Award). Streep's first film was *Julia* (1977); it was followed by notable performances in *The Deer Hunter* (1978), *Manhattan* (1979), *The French Lieutenant's Woman* (1981), *Silkwood* (1983), *Out of Africa* (1985), *Ironweed* (1987), and *Postcards from the Edge* (1990). She has won two Academy Awards, one (supporting) for *Kramer vs. Kramer* (1979) and the other for *Sophie's Choice* (1982).

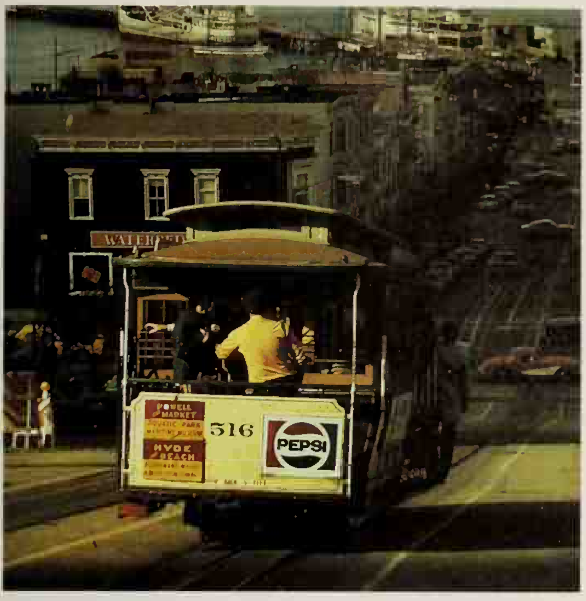
streetcar Streetcars, or trolley cars, are public passenger vehicles that run on railway tracks set in the street. Power is usually drawn from an overhead electric wire and is brought to the car through a spring-loaded trolley pole, or pantograph. Passengers board from street level, as they do with buses.

The first streetcars were pulled by horses in 1832 in New York City. The low friction of a metal wheel on a metal rail permitted a given horsepower to move more people more quickly than was otherwise possible. With substantial urban growth in the 19th century, cities throughout the world began to utilize the horse-drawn streetcar.

The components of the electric streetcar were developed in the 1880s, and a practical system of electric railway traction was developed by Frank J. Sprague in 1888. It was quickly adopted in urban transportation, and more than 40,000 km (25,000 mi) of street railways were operating in the United States by World War I.

Starting in the early 1920s the streetcar began to decline as a means of transportation, primarily because of the growing competition from automobiles. Disinvestment in the 1920s, '30s, and '40s almost brought an end to the streetcar in the United States.

A modern offshoot of the traditional streetcar is the light rapid-transit vehicle. Light rapid-transit vehicles can operate at much higher speeds than the traditional street-



The cable car has been carrying passengers up the steep hills of San Francisco since 1873. The cars are drawn by a wire rope, or cable, which runs on rollers through a groove in the tracks, powered by a stationary steam engine.

car because they run on their own private right-of-way rather than on the street.

Streetcar Named Desire, A Tennessee WILLIAMS's most popular play, *A Streetcar Named Desire* (1947; film, 1951), is both grimly naturalistic and poetically symbolic. Typical of Williams in its characters and theme, *Streetcar* pits Blanche DuBois, a neurasthenic, faded Southern belle who represents the culture and beauty of the past as well as its decadence, against her brother-in-law, Stanley Kowalski, the personification of modern practicality, crudeness, cynicism, and brutality. Blanche's childlike helplessness, romantic yearnings, and pretensions to gentility, sharply at odds with her age and the squalor of her present surroundings—her sister's New Orleans tenement—suggest an already tenuous hold on reality that completely collapses when Stanley's ruthless exposure of her past brings about Blanche's final disintegration. The winner of a Pulitzer Prize in 1948, *A Streetcar Named Desire* catapulted its male lead, Marlon BRANDO, to stardom, and his "method" style of acting to national prominence.

Streisand, Barbra [stry'-zand] The singer and actress Barbra Joan Streisand, b. Brooklyn, N.Y., Apr. 24, 1942, is perhaps the most versatile superstar of recent decades. Streisand's first (1963) and succeeding albums have been very successful, and she has won several Grammy awards. She achieved both stage and film stardom with her portrayal of comedienne Fanny Brice in *Funny Girl* (1965; film, 1968, Academy Award). Her other films include *Hello, Dolly!* (1969), *The Owl and the Pussycat* (1970), *The Way We Were* (1973), *Funny Lady* (1975; again as Fanny Brice), and *Nuts* (1987). Steisand directed, starred in, and cowrote the screenplay for *Yentl* (1983), based on an I. B. Singer story.

strep throat Streptococcal sore throat, or strep throat, is an inflammation of the throat and tonsils caused by bacteria of the group A β hemolytic *Streptococcus*, hence its name. It is the most common type of strep infection. The onset is usually sudden and is accompanied by pain, redness, and swelling in throat tissues, along with pus on the tonsils, fever, headache, and malaise. Abdominal pain and nausea also may occur, especially in children. The peak incidence of strep throat occurs in winter. Penicillin is considered the best therapy unless the patient is allergic. SCARLET FEVER is a type of streptococcal sore throat. Viral infections can mimic strep throat.

Streptococcus [strep-tuh-kahk'-uhs] *Streptococcus* is a genus of spherically shaped bacteria that, microscopically, appear in chains. Some streptococci are normal inhabitants of the human mouth, throat, intestine, and vagina, or of milk; others are important causes of animal infections and of such human infections as RHEUMATIC FEVER, SCARLET FEVER, STREP THROAT, TONSILITIS, and glomerulonephritis. *S. pneumoniae*, commonly called pneumococcus, is the most frequent cause of human lobar PNEUMONIA.

streptomycin see ANTIBIOTICS

Stresemann, Gustav [shtray'-ze-mahn] Gustav Stresemann, b. May 10, 1878, d. Oct. 3, 1929, German political leader, was chancellor (1923) and foreign minister (1923–29) of the Weimar Republic. In 1907 he was elected to the German parliament, the Reichstag, as its youngest member. An ardent nationalist and advocate of a strong military and naval establishment, he was a supporter during World War I of the policies of Paul von HINDENBURG and Erich LUDENDORFF.

The crushing terms of the Versailles Peace Treaty drove many embittered patriots into blind opposition, but Stresemann saw the necessity of accepting the odious consequences of defeat. In 1923, after the French occupied the Ruhr district and German passive resistance led to runaway inflation, Stresemann became chancellor. Under his leadership and with the support of President Friedrich EBERT, resistance to the French was ended and the economy provisionally stabilized. After 3 months, Stresemann relinquished the chancellorship but remained foreign minister for the last 6 years of his life, during which he succeeded in reconciling France and Germany and in bringing Germany into the League of Nations. Jointly with his French counterpart, Aristide BRIAND, he received the Nobel Peace Prize in 1926.

stress In psychology the term *stress* is used to refer both to certain heightened mental and physical states and to the causes of such states. A person in a physically or mentally demanding or dangerous situation is said to be under stress. Internal disorders such as acidosis, cirrhosis, and other conditions can also produce stress responses. Chronic repetition of certain emotions, such as anger or despair, as well as changes in work or home situations or a reaction to surgery are just a few of the further ways in which stress can occur.

Stress is a normal part of life, and such producers of stress as physical exercise, various emotional states, and creative activity are usually considered healthy. Prolonged and unwanted stress, however, can have undesirable effects on mental and physical health, although reactions to such pressure can vary greatly among individuals. A number of stress-related disorders are known, even though the interactions of body and mind in the development of such disorders are not yet fully understood. Mental states such as severe melancholic DEPRESSION are closely linked with stress-inducing ANXIETY, and the complex syndrome known as POST-TRAUMATIC STRESS DISORDER is produced by traumatic situations such as war and disaster. Physiological effects linked with stress include ULCERS, high blood pressure (see HYPERTENSION), and HEART DISEASE. Stress can also adversely affect the immune system, causing the body to be less resistant to a wide range of other health problems (see IMMUNITY).

When the human body perceives danger (whether real or imaginary), the pituitary gland releases adrenocorticotropic hormone. This triggers the adrenal glands to release various other hormones that speed up the heart rate, raise blood pressure, and increase muscle tension. These same responses may result from occupational or emotional stress. Usually such responses are of short duration. If they persist, they can lead to the above-mentioned mental and physical problems.

Various methods have been developed to cope with stress, including medications such as TRANQUILIZERS and various forms of PSYCHOTHERAPY.

See also: PREMENSTRUAL SYNDROME.

Strickland, William [strick'-luhnd] William Strickland, b. Navesink, N.J., 1788, d. Apr. 6, 1874, was an influential American architect of the 19th-century GREEK REVIVAL. His Second Bank of the United States (1818–24) in Philadelphia, for example, builds on classic Greek prototypes with unprecedented faithfulness. His many public commissions included the United States Mint (1829–23) and the Navy Hospital (1827–48) in Philadelphia, the New Orleans Mint (1835–36), and the Providence Athenaeum (1838). Considering the Tennessee State Capitol at Nashville (1844–55) to have been his finest work, Strickland arranged to have himself interred there. Others, however, consider Strickland's masterpiece to be the Merchants' Exchange (1832–34) in Philadelphia; the stately main block of the building is set off by an elegantly detailed semicircular end wing with an open Corinthian colonnade and a tall columned lantern tower.

strike A strike is a concerted effort by a group of workers to withhold their labor from their employer, for the purpose of effecting favorable changes in wages or working conditions or both, or for winning employer recognition of LABOR UNION representation. Strikes can take different forms: a primary strike is a stoppage aimed at the direct employer; a sympathy strike occurs when employees refuse to work in "sympathy" with others directly involved in a dispute; and a sit-down strike happens when workers stop work and decline to leave the employer's premises in order to prevent the hiring of replacements. A wildcat strike is one that occurs without formal union authorization, and a GENERAL STRIKE is an effort to stimulate a generalized work stoppage and has political overtones. All of the above have been common in the United States, with the exception of the politicized general strike, a technique that is most often practiced in Europe and Third World nations.

Conducting a Strike. A strike is a test of economic strength: the union tries to prevent operations and cause a loss of profits to the employer in order to force changes, while the employer tries to maintain profitability and resume operations as economic pressures from loss of pay mount to force workers to return to work.

During the negotiations for a contract or contract renewal, unions will typically take a "strike authorization" vote to determine the will of the membership if a bargaining impasse is reached. The union will then designate a "strike deadline" beyond which it is assumed there will be a cessation of work should no agreement occur. Should that deadline pass, the strike begins with a formal authorization by the union to its members not to report for work (or, alternatively, when the employer acts preemptively for tactical reasons and declares a LOCKOUT, a refusal to allow workers on the premises, prior to that union order). The union will attempt to prevent the employer from continued operations by picketing the employer's facilities (walking up and down outside the employer's premises carrying picket signs), thereby announcing the existence of a labor dispute and asking the other workers and the public not to cross the picket lines. While on strike, workers usually receive "strike benefits" from their union, a small money stipend to help them with their necessary expenses.

As negotiations continue during the course of the strike, the parties may find the use of a mediator—a neutral third party who attempts to open lines of communication and suggests alternative resolutions perhaps as yet unthought of—to be of value. Upon reaching contractual agreement, union members vote to accept or reject the terms of the contract in a "ratification" meeting.

Legal Aspects. In the United States the basic right to strike and to picket is legally protected under the NATIONAL LABOR RELATIONS ACT (NLRA) of 1935 (as amended by the Taft-Hartley Act in 1947 and the Landrum-Griffin Act in 1959), except in the public sector, where strikes against state or local governments are often illegal. In the private sector, federal law affords the most protection to primary strikes against the direct employer. Even here, however, there are restrictions if an illegal technique like the sit-down is used or if the conflict is of sufficient import for the U.S. president to declare it a "national emergency strike" under the provisions of the Taft-Hartley Act.

History. The legal status of strikes earlier in U.S. history was similar to the current situation in the Third World. In the early 19th century, starting with the Philadelphia cordwainer case of 1806, courts regarded unions and their strikes as illegal combinations in restraint of trade. As time progressed, court involvement in restricting strikes abated somewhat. But since as yet there were no legislative protections of the right, employers and unions battled in violent strike outbursts often erupting in the wake of employer-imposed wage cuts, the great railroad strikes of 1877 and the Homestead (steel) Strike of 1892 being prime examples.

In 1894, as a result of the Pullman (railroad) Strike, the U.S. government successfully applied the Sherman Anti-Trust Act to union strike activity, making it easy for employers to obtain federal court injunctions against any strike that affected interstate commerce. That essentially remained the state of affairs until the 1930s, when the depression spawned the NLRA and the successful 1937 Great Flint (Mich.) Sit-Down strike against General Motors gave birth to what was to become a far more powerful labor movement through the late 1970s. In the 1980s, labor's power waned, and the strike weapon became less effective, causing unions to consider using alternative means to achieve their objectives.

See also: arbitration (labor-management and commercial); mediation.

Strindberg, August [strind'-burg] A major figure in world drama whose plays have exerted a seminal influence on such 20th-century developments as expressionism, surrealism, the "psychoanalytic" play, and the theater of the absurd, August Strindberg b. Stockholm, Jan. 22, 1849, d. May 14, 1912, was the Swedish language's great teacher of modern prose style and a forerunner of modernity in international theater.

In summers (1871–83) spent on Kymmendö, an island in Stockholm's archipelago, Strindberg achieved a personal breakthrough in the prose draft of his first notable play, the historical drama *Mäster Olof* (1872; Eng. trans., 1915), an event that was followed by his appointment (1874–82) to the staff of Stockholm's Royal Library and the publication of his realistic novel of social criticism, *The Red Room* (1879; Eng. trans., 1913).

Something of a misogynist, Strindberg ultimately married and divorced three times and fathered five children. Not surprisingly, the theme of sexual conflict is often reflected in his works, notably in the naturalistic plays *The Father* (1887; Eng. trans., 1899) and *Miss Julie* (1888; Eng. trans., 1912).

Strindberg's literary career was interrupted by his "Inferno crisis" (1894–97), a period of deliberate isolation and exile and intense physical and spiritual suffering. In all, however, he wrote more than 60 plays, as well as novels, short stories, essays, verse, cultural studies, popular and esoteric science, works on history, philology, and religion, and a nine-volume autobiography (1886–1908; Eng. trans., 1966).

The Swedish playwright and novelist August Strindberg defied social convention by writing dramas of sexual conflict and psychological torment, drawn largely from his personal life. His plays are now esteemed as classics of the modern stage.

The best of Strindberg's dramatic work tends to overlap the boundaries of several genres. His verse and prose fiction—with the exceptions of *The Red Room*, the regional novel *The Natives of Hemsö* (1887; Eng. trans., 1959), the humanly wise narrative *The Scapegoat* (1907; Eng. trans., 1967), and perhaps the mordant satire of *Svarta fanor* (Black Banners, 1907)—do not rank with the finest or most significant that Swedish literature has produced. In the theater, however, Strindberg achieved lasting international distinction.

Strindberg's straining and breaking of the conventions of the late-19th-century stage furnished an impetus for virtually every aspect of the dramatic avante-garde in the 20th century. Although his point of departure was the realistic theater of his time, he prepared the way for expressionistic drama; with *A Dream Play* (1902; Eng. trans., 1912) he contributed significantly to both the dream play and the "supernaturalistic" play; with the three-part *To Damascus* (1898 and 1904; Eng. trans., 1939), The *Ghost Sonata* (1907; Eng. trans., 1916), and *The Vasa Trilogy* (1899; Eng. trans., 1931) he also affected the development of modern symbolic, intimate, and historical drama.

string quartet The string quartet is a musical genre that originated in the early 18th century, the same name being given to a group of four players (two violinists, a violist, and a cellist) who interpret this kind of music. Performing groups generally omit the word *string* and substitute a professional name, such as Budapest Quartet or Juilliard Quartet. Although the earliest composers of string quartets were Italian, it was because of Haydn and Mozart that the classical repertoire and form became firmly established, with the typical sequence of four movements as in a SONATA or symphony.

Eventually all the instruments were equally involved in both textural and thematic development, so that when Beethoven took up the form, it reflected his new ideas, and in three of his last quartets he expanded the usual four-movement cycle to five, six, and seven movements.

The challenge of the string quartet has remained irresistible to serious composers from Beethoven's time to the present. If technical demands made on the players have increased over the past century, it is also true that there are considerable challenges, especially for the first violinist and cellist, in many of the quartets by Haydn and Mozart and for all four players in the works of Beethoven.

stringed instruments see MUSICAL INSTRUMENTS

strip mining see COAL AND COAL MINING

stroboscope [strahb'-uh-skohp] A stroboscope is a device that employs bright pulses of light to illuminate a vibrating or rotating object and to make it appear motionless or moving very slowly. The stroboscope works by permitting the eye only a brief glimpse of the object or a portion of it at time intervals that correspond to the object's rate of vibration or rotation. The rate of movement and the light pulses can be adjusted to match. An early stroboscopic device, invented in 1836 by Joseph Plateau of Belgium, used a disk with radial slits that he turned while viewing a rotating wheel; when the rotational speed of the disk and the wheel matched exactly, the wheel appeared motionless. Other pioneers employed rotating or vibrating mirrors to produce light pulses. By the later 19th century the camera was being used to capture stroboscopic images for motion studies, and stroboscopic PHOTOGRAPHY has since become the major application for these devices. The use of stroboscopic photographs to produce the illusion of motion also led to the development of motion pictures.

The modern stroboscope, an electronic device, was first brought to perfection (1931) by the American scientist Harold EDGERTON. Such devices can produce flashes equivalent to 50,000 watts of incandescent light. A typical flash lasts roughly five-millionths of a second, and 100 such flashes may be produced each second. Stroboscopes are commonly available for setting the ignition timing of motor vehicle engines. They are also used industrially when moving machines must be checked for quality, and in the laboratory for studying mechanical systems in motion. Simple stroboscopes are sometimes used for stage-lighting effects.

Stroessner, Alfredo [strurs'-nur] Dictator of Paraguay for 35 years, Alfredo Stroessner, b. Nov. 3, 1912, was the grandson of a German immigrant. He entered military service in 1932 and became commander of chief of the armed forces in 1951. After toppling the government of Federico Chávez in a coup in 1954, Stroessner was elected president. On Feb. 3, 1989, during his eighth successive presidential term, Stroessner's repressive regime was overthrown by Gen. Andrés Rodríguez. Stroessner was flown into exile in Brazil.

Stroheim, Erich von [shtroh'-hym] A legendary figure in the Hollywood of the silent era, actor, director, and scriptwriter Erich von Stroheim, b. Vienna, Sept. 22, 1885, d. May 12, 1957, is celebrated both for his ruinous extravagances as a filmmaker and for his screen portrayals of stiff-necked German officers. His only successfully completed films—*Blind Husbands* (1919), *The Devil's Passkey* (1919), and *Foolish Wives* (1921), in two of which he played the lead—bear the stamp of his wit, sophistication, lavish attention to detail, and sometimes brutal realism. His ambitious artistic schemes for such films as *Merry-Go-Round* (1922), *Greed* (1923), and *The Wedding March* (1926) repeatedly ran afoul of producers at Universal, MGM, and Paramount, who cut and distorted his work beyond recognition. His most famous failure, *Queen Kelly* (1928), effectively ended his directorial hopes. Concentrating exclusively on acting after 1936, von Stroheim gave his most distinguished performances in Jean Renoir's *Grand Illusion* (1937) and in Billy Wilder's inspired film à clef, *Sunset Boulevard* (1950).

stroke Stroke, also known as cerebrovascular accident (CVA), involves damage to the brain because of impaired blood supply and causes a sudden, nonconvulsive malfunction of the brain. In the United States, stroke is the third-ranking cause of death after heart disease and cancer, and about one-fourth of the neurologic patients in nursing homes are stroke victims.

Stroke victims are generally elderly people with degeneration of blood vessels, but children and young adults also can be subject to stroke. People having HYPERTENSION, ATHEROSCLEROSIS, HEART DISEASE, or DIABETES mellitus or who are emotionally upset incur a high risk of having a stroke, and cigarette smoking significantly increases the risk. Women using oral contraceptives are more prone to cardiovascular disease than those using other means of birth control.

Symptoms

A stroke may be mildly incapacitating or may involve a sudden coma, followed by headache, nausea, confusion, and stupor. Stroke patients are often characterized by paralysis of one side of the body (hemiplegia), accompanied by loss of speech or comprehension. The initial paralysis of a stroke victim is flaccid or soft because of central-nervous-system shock, but spasticity occurs as spinal motor neurons resume function, making muscles tighten and the limbs progressively contract. A stroke patient with paralysis of an arm, for instance, will initially have a loose, freely swinging arm. Months later the arm will be rigidly flexed, with the wrist and hand positioned near the shoulder. Physiotherapy is often undertaken to preserve the motor abilities of a contracted limb.

Patient Care

The medical team involved in caring for stroke victims includes an internist, a neurosurgeon, a neurologist, a stroke nurse, a physical therapist, an occupational therapist, and a speech therapist. These people are involved not only in the care of the stroke patient but also in educating the patient's family in long-term care and rehabilitation.

Types of Strokes

Ischemia. About 63% of strokes are caused by ischemia, which is a narrowing or blockage of an artery by means of atherosclerosis or by an embolus. Atherosclerosis, or hardening of the arteries, produces ischemia by obstructing vessels with fat derivatives. Most frequently, cholesterol forms plaques that build up on arterial walls, reducing the passage of blood.

Another form of ischemia is thrombosis, or blockage resulting from an embolus. For example, a clot, or thrombus, can form in the carotid artery (which supplies blood to the brain) and fragment, producing a thromboembolus that travels to the brain and becomes entrapped in a cerebral artery.

Treatment of thromboemboli of the carotid artery may require surgical removal of plaque, a bypass graft, anticoagulants, modified diet, anaerobic exercises, reduced stress, or simply two aspirins twice a day for life.

Hemorrhage. About 22% of all strokes are caused by cerebral hemorrhage. Causes of spontaneous intracranial hemorrhage, commonly called apoplexy, are hypertension, aneurysm, bleeding into a tumor, and generalized bleeding. Hypertensive hemorrhages occur in the brain stem or the cerebral hemisphere near the pathway for motor nerves; if the hemorrhage extends into the motor tract, hemiplegia will result. Partial or complete recovery of function can return, and treatment is aimed at reducing blood pressure and regaining the use of the limbs. A massive hemorrhage, however, can result in coma, brain damage, and possibly death.

Aneurysms—enlargements of small portions of blood vessels—can hemorrhage and cause stroke if present in the brain or arteries of the neck. After an aneurysm ruptures, creating a massive bleeding episode, red blood cells degenerate and release products that can promote a vascular spasm. An aneurysm is usually treated surgically after a 2-week waiting period, which allows edema and vasospasm to subside. Often, however, bleeding begins again and is frequently fatal.

Tumors, to obtain an adequate blood supply to maintain their growth, may secrete an angiogenesis factor that promotes blood-vessel growth. Too much of this factor causes the vessels to enlarge, which can result in internal hemorrhage and sudden stroke.

Generalized bleeding used to be restricted to hemophilia and related disorders. Chemotherapy of tumors, however, poisons bone marrow and interferes with the production of platelets necessary for the formation of clots if bleeding should occur, increasing the chances for incurring a stroke.

Diagnosis

Diagnostic techniques include searching for blood in a lumbar puncture (spinal tap), injecting radiopaque dyes into vessels (arteriogram), using brain scan to detect defects in blood-brain barrier, and doing computerized tomography (CAT scan) to search for altered density within the brain.

stromatolite [stroh-mat'-uh-lyt] Stromatolites are variously shaped laminated structures that occur as fossils in many tidal-flat limestones. They were originally considered to be animal fossils. Geologists have since found modern examples of these structures forming in shallow water underneath sticky mats of blue-green and green algae. The mats trap carbonate sediment, and as the algae grow upward, the sediment is incorporated in layers. After deposition, the organic mats decompose, and only the layered sediments remain. Fossil stromatolites have assumed great importance as evidence of algal life far into the Precambrian era. Formations of stromatolitic limestones over 2 billion years old have been mapped in Canada and South Africa.

Stromboli [strom'-boh-lee] Stromboli is an active volcano, 926 m (3,038 ft) high, on an island of the same name in the Lipari Islands in the TYRRHENIAN SEA, 64 km (40 mi) north of the northeast coast of Sicily. The volcano, which occupies most of the island's 13-km^2 (5-mi^2) area, is a popular tourist attraction. Records of its continuous activity date from the 6th century BC. The last major eruption occurred in 1921, but the volcano still emits smoke.

Strong, Josiah The American cleric Josiah Strong, b. Napierville, Ill., Jan. 19, 1847, d. Apr. 28, 1916, was a leader of the SOCIAL GOSPEL movement, which called for Christian service to promote human welfare. An Ohio minister, he moved (1886) to New York after his first book, *Our Country* (1885), had made him a national figure. Strong used statistical evidence to show how wealth had been concentrated in the hands of a few and how industrial workers were deprived of decent living conditions. He insisted that Christianity had the duty to alleviate such inequities and to help achieve the standard of social justice articulated in the Bible. In 1898 he organized the League (later the American Institute) for Social Service.

strong interactions see FUNDAMENTAL INTERACTIONS

strontium Strontium is a soft, silvery metal with physical and chemical properties similar to those of calcium. Its symbol is Sr, its atomic number is 38, and its atomic weight is 87.62. First isolated (1808) by Sir Humphry Davy, strontium is found in the minerals strontianite and celestite. Many radioactive isotopes of strontium are produced in nuclear reactors. Strontium 90, with a half-life of 28 years, is formed in nuclear explosions;

because it accumulates in the bones, it is considered the most dangerous component of radioactive FALLOUT. Strontium salts impart red color to flames and are used in red signal flares, fireworks, and tracer bullets.

structuralism Structuralism is a mode of thinking and a method of analysis practiced in 20th-century social sciences and humanities. Methodologically, it analyzes large-scale systems by examining the relations and functions of the smallest constituent elements of such systems, which range from human languages and cultural practices to folk tales and literary texts.

In the field of linguistics the structuralist work of Ferdinand de Saussure, undertaken just prior to World War I, long served as model and inspiration. Characteristic of structuralist thinking, Saussure's linguistic inquiry was centered not on speech itself but on the underlying rules and conventions enabling language to operate.

In anthropology and myth studies, the work done immediately after World War II by Claude LÉVI-STRAUSS introduced structuralist principles to a wide audience. Following the ideas of Saussure and of the Slavic linguists N. S. Trubetzkoy and Roman Jakobson, Lévi-Strauss specified four procedures basic to structuralism. First, structural analysis examines unconscious infrastructures of cultural phenomena; second, it regards the elements of infrastructures as "relational," not as independent entities; third, it attends single-mindedly to system; and fourth, it propounds general laws accounting for the underlying organizing patterns of phenomena.

In humanistic and literary studies, structuralism is applied most effectively in the field of "narratology," which studies all narratives, whether or not they use language: myths and legends, novels and news accounts, histories, relief sculptures and stained-glass windows, pantomimes and psychological case studies. Starting in the 1960s, the French critic Roland BARTHES and several other French narratologists popularized the field.

At the moment when structuralist methodology was expanding into the discipline of SEMIOTICS, critical reaction occurred, particularly in France, where it led to such antithetical and schismatic projects as Gilles Deleuze's "schizoanalysis," Jacques Derrida's DECONSTRUCTION, Michel Foucault's "genealogy," and Julia Kristeva's "semanalysis." These critical schools were lumped together and labeled *poststructuralism* in the United States.

Struthiomimus [stroo-thee-oh-my'-muhs] *Struthiomimus* is one of the "ostrich" dinosaurs of the family Ornithomimidae, suborder Theropoda, order Saurischia. It lived during the late Cretaceous, about 75 million years ago, in western North America and Asia. Except for a long tail, *Struthiomimus* and its close relatives were ostrichlike and were characterized by long, slender legs that suggest very fast running ability, long arms and hands designed for grasping, a long, flexible neck, and a relatively small, birdlike head with large eyes and a toothless beak. They stood 2.4 m (8 ft) high and reached 4.3 m (14 ft) in length, including the tail; some weighed up to perhaps 200 kg (440 lb). Despite its toothlessness, *Struthiomimus* is a member of the carnivorous theropod group. Possibly the animals were omnivores or egg-eaters. Other ostrich dinosaurs are *Ornithomimus* (probably identical to *Struthiomimus*), *Dromiceiomimus* from North America, and *Gallimimus* from Mongolia.

strychnine [strik'-nyn] Strychnine is a natural alkaloid found in the tree genus *Strychnos*, particularly *S. nux vomica*, which grows in India, Burma, China, and northern Australia. It was isolated (1818) from the seeds of these trees, which were used in earlier centuries as a medicinal tonic and a stimulant to the intestines. Strychnine is a potent stimulant of the central nervous system, and a lethal dose in humans first causes convulsions, twitching, arching of the back, and a rigidity of facial muscles. Today strychnine is used mainly as a poison for rats and other rodents.

Stuart (family) The Stuart (also spelled Stewart and Steuart) family provided Scotland and, later, Britain with numerous monarchs. The family can be traced to a Breton, **Alan**, the son of Flaald, who migrated to England about the beginning of the 12th century. **Walter**, d. 1177, his youngest son, was made steward (official in the household) by David I of Scotland, who granted him lands in Renfrewshire.

The 6th steward, **Walter**, d. 1326, married Marjory, daughter of Scotland's King Robert I, and in 1371 their son Robert II became the first Stuart king of Scotland. His successors were Robert III; JAMES I; James II; James III; JAMES IV; JAMES V; MARY, QUEEN OF SCOTS; and James VI. In 1603, James VI became JAMES I of England as well. His Stuart successors on the thrones of England and Scotland were CHARLES I, CHARLES II, James II, MARY II, and ANNE. With the death of Anne in 1714, the Stuart dynasty was replaced by the Hanoverians (whose claim to the throne also sprang from the Stuarts). However, male descendants of James II—most notably James Francis Edward STUART (the Old Pretender) and Charles Edward STUART (the Young Pretender)—attempted unsuccessfully to recover the throne for the family.

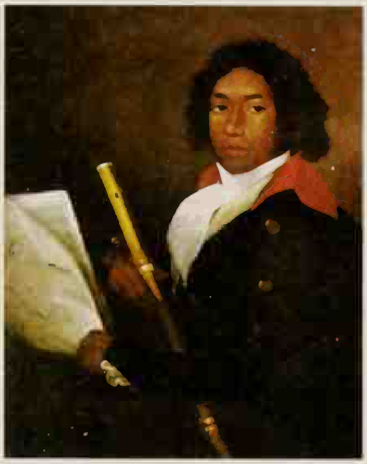
A strong branch of the family held the earldom and later dukedom of Lennox. The 4th earl, **Matthew Stewart** (1516–71), married Margaret Douglas, daughter of Margaret Tudor and the 6th earl of Angus; their son Henry Stewart, Lord DARNLEY, stood next to Mary, Queen of Scots, in the English succession. When Darnley married Mary in 1565, the branches of the powerful Stuart family united. The dukedom of Lennox was created in 1581 for **Esmé Stuart** (*c.*1542–83) by his cousin James VI.

Stuart, Charles Edward (Bonnie Prince Charlie) Charles Edward Stuart, known as Bonnie Prince Charlie and as the Young Pretender, b. Rome, Dec. 31, 1720, d. Jan. 31, 1788, laid claim to the British throne through his Stuart grandfather, King James II. Charles Edward was the elder son of James Francis Edward Stuart (the Old Pretender). In 1744 he went to France hoping to participate in an invasion of Britain. When it failed to materialize, he and his companions left France for Scotland and landed in the Hebrides in July 1745. They launched the Jacobite rebellion known as the '45, the last Stuart attempt to regain power in Britain.

Charles Edward raised his standard in the Highlands and attracted a number of loyal clans. His support, however, was not broadly based. He defeated Sir John Cope at Prestonpans on Sept. 21, 1745, and with an army of 7,000 to 8,000 men he marched toward London. He stopped at Derby and waited in vain for promised French and English aid; then he retreated to Scotland. Outside of Inverness, at Culloden Moor, Charles Edward's army was badly defeated on Apr. 16, 1746, by troops led by the duke of Cumberland. With the help of Flora Macdonald, Charles Edward fled to France. Bonnie Prince Charlie has been the subject of many romantic legends.

Charles Edward Stuart, the legendary Bonnie Prince Charlie, sought to recover the British throne for the Stuart family in the Jacobite uprising of 1745. Disastrously defeated at Culloden Moor, where one-fifth of his Highland army was killed in battle, the Young Pretender fled to the Continent.

Stuart, Gilbert Gilbert Stuart, b. North Kingston, R.I., Dec. 3, 1755, d. July 9, 1828, a major American portrait painter of the late 18th and early 19th centuries, is among the greatest portraitists in the history of American art. He executed his earliest works in a provincial, quasi-primitive style. At the outbreak of the Revolution he went (1775) to London, where he studied under Benjamin West. By the 1780s, Stuart's earlier provincialism had given way to a highly sophisticated style marked by coolly rational likenesses created with warm color and fluid brushwork. His London reputation was secured with the favorable reception accorded to his *Skater* (1782; National Gallery, Washington, D.C.), the only work in which Stuart showed his subject in motion.



Portrait of a Flute Player (c. 1795–98), painted by Gilbert Stuart, an important late-18th-century American portraitist, is quiet, naturalistic, and straightforward. Stuart gained much acclaim during his lifetime, especially for his portraits of George Washington and other prominent Americans of his time. (Private collection.)

Universally recognized as the finest portraitist in the United States, he was much in demand and painted hundreds of likenesses. His three portraits of George Washington (1795–96) proved to be so popular that he painted more than 100 replicas to meet the demand. He also painted the next five presidents, as well as many of the most prominent Americans of his day. For his American work he developed a plain, forthright portrait style best seen in his unidealized depiction of Washington as a citizen-president, without any insignia of rank or office. Fittingly, one of his portraits of Washington, the "Athenaeum" version (1796; Museum of Fine Arts, Boston), was adopted for the U.S. one-dollar bill.

Stuart, James Francis Edward James Francis Edward Stuart, known as the Old Pretender, b. June 10, 1688, d. Jan. 1, 1766, attempted to regain the throne of England and Scotland for the direct male line of the Stuart family. He was the son of King James II, a convert to Roman Catholicism, and Mary of Modena. Prior to his birth, the heir presumptive to the throne was his elder half sister, Mary (later Mary II), a Protestant. The birth of a Catholic heir was the pivotal cause of the Glorious Revolution, which resulted in James II's exile. In 1701, James II died, and his son inherited the Stuart claim to the throne, although the Act of Settlement, passed that year by Parliament, barred James Francis from the throne. He and his followers, known as Jacobites, hatched various schemes for his restoration. His first attempt (1708) was thwarted by the weather and the English navy. The second attempt (1715) was made when the 6th earl of Mar gathered a broad base of support for him in the Highlands, but by the time James Francis landed at Peterhead, the cause was lost. He and the earl of Mar fled to France on Feb. 4, 1716. In 1719, James Francis married Princess Clementina Sobieski, granddaughter of the king of Poland; one of their sons was Charles Edward Stuart, known as the Young Pretender.

Stuart, J. E. B. James Ewell Brown (Jeb) Stuart, b. Patrick County, Va., Feb. 6, 1833, d. May 12, 1864, was a Confederate cavalry officer in the U.S. Civil War. He

Jeb Stuart, a Confederate cavalry commander in the U.S. Civil War, achieved fame by his brilliantly executed reconnaissance missions and raids behind federal lines. One such raid, however, delayed his arrival at Gettysburg, depriving Gen. Robert E. Lee of vital intelligence on federal positions.

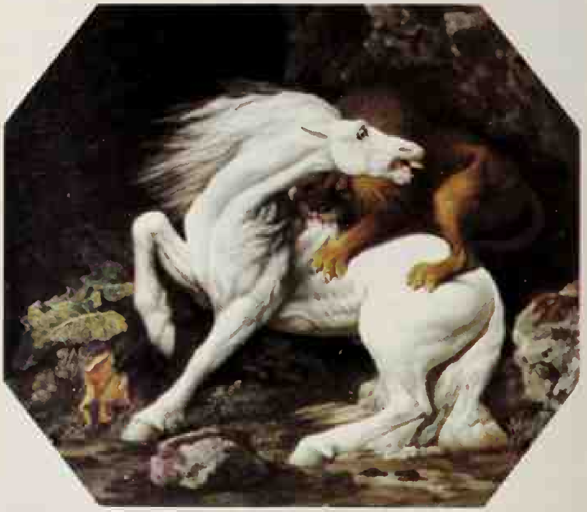
graduated from West Point in 1854 and served in the Mounted Rifles until he joined the Confederacy in 1861. Commissioned into the cavalry, he became one of the most famous and popular of Robert E. LEE's subordinates. In 1862, Stuart took command of Lee's mounted units, and after playing a pivotal role in the PENINSULAR CAMPAIGN he fought brilliantly at the Second Battle of BULL RUN, the Battle of ANTIETAM, and Fredericksburg (see FREDERICKSBURG, BATTLE OF).

At CHANCELLORSVILLE (May 1863) Stuart briefly but splendidly led Gen. Stonewall JACKSON's corps after Jackson was wounded. In the Gettysburg campaign (see GETTYSBURG, BATTLE OF; June–July 1863) Stuart, taking advantage of ambiguous orders, embarked on a controversial raid around the Federal army. As a result, he was absent when Lee most needed him to gather intelligence about the enemy, arriving only after the battle was already lost. Some historians believe that the Confederate defeat at Gettysburg was primarily Stuart's fault. Certainly, had Stuart been present earlier, Lee would have fought a different battle. On May 11, 1864, at Yellow Tavern, Va., Stuart was mortally wounded. He died the following day.

Stuart, John McDouall John McDouall Stuart, b. Sept. 7, 1815, d. June 5, 1866, was a Scottish-born explorer of South Australia. A draftsman, he accompanied Charles Sturt's expedition (1844–45) from Adelaide, which failed to reach central Australia. Stuart made six expeditions between 1858 and 1862, reaching midcontinent in 1860. He succeeded in pushing through to Van Diemen Gulf on the Indian Ocean in 1862.

Stubbins, Hugh The American architect Hugh Stubbins, Jr., b. Birmingham, Ala., Jan. 11, 1912, has designed many important buildings in the tradition of Walter Gropius and the International Style. He has headed his own architectural firm in Boston since 1941. His major works—including Citicorp Center and the adjoining Saint Peter's Lutheran Church (both completed 1977) in New York City and Pusey Library (1973–76) at Harvard University in Cambridge, Mass.—display elegantly simple profiles embodying imaginative technical solutions to challenging sites and building programs.

Stubbs, George The leading British animal painter of the 18th century, George Stubbs, b. Aug. 25, 1724, d. July 10, 1806, was largely self-taught as an artist. His passion for the mastery of anatomy led him to spend 2 years (1756–58) dissecting horses. He engraved the resulting drawings, which appeared in the book *The Anatomy of a Horse* (1766). From 1760 onward he lived in London, establishing a reputation as a painter of horses. During this period he produced *Mares and Foals by a Stream* (1763–64; private collection, England) and *The Grosvenor Hunt* (1762; Trustees of the Grosvenor Estate, London); wild animals are the dramatic protagonists of *Nyl-Ghau* (1769; Hunterian Collection, University of Glasgow) and *Horse Attacked by a Lion* (*c.*1762; Paul Mellon Collection, Yale Center for British Art, New Haven, Conn.). Toward the end of his life he was involved with an ambitious project for a comparative atlas of animal anatomy. His capacity for careful design made him one of the leading artists of his time.



In Lion Devouring a Horse *(1769), by the British painter George Stubbs, the figures of a terrified horse and a predatory lion are a romantic response to the beauty and savagery of the natural world. (Tate Gallery, London.)*

Studebaker (family) The Studebaker family firm became the world's largest producer of horse-drawn wagons and carriages in the late 19th century and in the 20th century became an early manufacturer of automobiles. **Clement Studebaker**, b. Pinetown, Pa., Mar. 12, 1831, d. Nov. 27, 1901, learned blacksmithing and wagonmaking from his father, who moved (1836) his family to Ohio. Clement moved (1850) to South Bend, Ind., to become a blacksmith and was soon joined by his elder brother, **Henry** (1826–95). In 1852 they started H. & C. Studebaker, a firm of blacksmiths and wagonmakers. Another brother, **John Mohler**, b. Oct. 10, 1833, d. Mar. 16, 1917, bought out (1858) Henry's interest and expanded the family business. Production of Studebaker automobiles began in 1901; in 1954 the firm merged with the Packard Company. Studebaker ceased producing in the United States in 1963 and was phased out in Canada in 1966.

student movements Student political movements are a worldwide phenomenon. Issues that have sparked college and university activists range from government policies to university reform to narrower campus matters, such as housing.

Students in the developing countries of the Third World have generally had a greater impact on their nations than have students in the industrialized world; Third World students are among a small number of articulate and literate people in their societies. Student movements tend to oppose the established order. More often than not, they are leftist and nationalist, but examples of right-wing activism include strong student support for Islamic fundamentalism in the contemporary Muslim world.

An early example of direct student impact on politics came in the German nationalist upsurge of the mid-19th century. University-based movements spread both the ideology and the activism that eventually resulted in a unified German nation. Similar developments took place in Italy. The early-20th-century university-reform movement of Latin American students not only transformed the universities and involved students directly in academic governance, but also stimulated liberal and radical social action in many South American nations. In the United States the 1930s witnessed the first major upsurge of student activism. These student movements were almost exclusively liberal or radical in orientation and focused both on foreign-policy issues (such as the rise of fascism in Europe or opposition to U.S. rearmament) and on the domestic crises engendered by the depression.

In the 1960s, major student movements occurred in the United States, Japan, Italy, France, West Germany, Mexico, and South Korea. In West Germany, the student movement was the major focus of antiestablishment sentiment. The West German students also forced from the government a university reform law that gave students direct participation in academic governance. In 1968 in France, students (backed by other groups) nearly caused the downfall of President Charles de Gaulle. In Mexico City in 1968, a prolonged student strike was suppressed by the government in a confrontation that left dozens dead.

Two issues fueled the most important student-protest movement in U.S. history—student support for civil rights for African Americans and opposition to the war in Vietnam. Led by SDS (Students for a Democratic Society), student protests focused attention on the plight of blacks in the U.S. South and the growing conflict in Vietnam. Tactics became increasingly radical as the U.S. war effort grew, with some U.S. student elements (and some of those abroad) eventually veering to TERRORISM. Incidents of official overreaction culminated in 1970 in the deaths of students at Kent State and Jackson State universities at the hands of armed authorities. The nation's universities were virtually shut down by a protest strike.

During the 1960s students also demanded free speech on campus (notably at Berkeley, Calif.) and changes in curricula and in university administration and regulation of student life. The student movement contributed to ending the war in Vietnam by arousing public opinion, but it probably left its greatest mark by changing the cultural norms of the nation.

In the United States and Europe, student activism declined after the 1960s. It continued to be important in such countries as South Korea, however, and in China, where student prodemocracy demonstrators were massacred by the army in June 1989.

Student Nonviolent Coordinating Committee see SNCC

Stuka [stoo'-kuh] A two-seat, inverted-gull-wing monoplane with a 13.7-m (45.1-ft) wingspan, the Junkers Ju-87 Stuka gained immediate notoriety in the first few months of World War II as it blasted a noisy, destructive path for the German army's advances across Poland, Belgium, Holland, and France. The Stuka originated in 1928 with the Swedish-built K-47 and by 1935 had evolved into an angular, all-metal, Junkers Jumo-powered dive-bomber that carried its single bomb between nonretracting main wheels. Two sirens were fitted to operate as terror weapons during the dive attack, and later versions of the plane had increased power, different combinations of

The Junkers Ju-87 Stuka, a slow, heavy dive-bomber, enjoyed its most notable success during the early stage of World War II, providing support for ground troops in the Nazi blitzkrieg.

machine guns and cannon, and other modifications. Evaluated initially in the Spanish Civil War, the Ju-87 served throughout World War II and in addition to its bombing duties was used for ground strafing over southern England and on the Russian front.

stupa [stoo'-puh] A stupa (Sanskrit for "mound") is a Buddhist monument of moundlike shape. Originating in the funeral mound that customarily was piled up over the remains of Indian princes and holy men, the stupa developed into a principal Buddhist shrine commemorating the Buddha's triumph over life. Many thousands of stupas were erected in India during the reign (*c*.273–232 BC) of Emperor ASOKA, and stupas eventually appeared in every region in which Buddhism flourished.

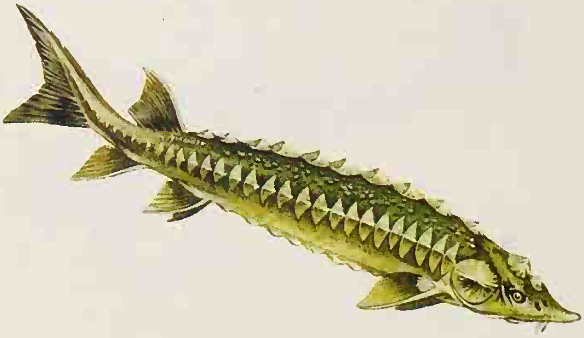
In substance the stupa is an artificial mountain formed of mounded rubble and sheathed in the more permanent materials of brick, plaster, or stone, which also have served to ennoble it through ornamentation. In its developed Buddhist form, whatever its scale or the materials of its manufacture, the stupa is understood to be a cosmograph and therefore an appropriate vehicle for the expression of the universal significance of the nirvana of the Buddha.

sturgeon [stur'-juhn] Sturgeons, family Acipenseridae, are among the most primitive of the actinopterygian (ray-finned) fishes. They are elongate fishes with a sharklike caudal fin and an inferior mouth preceded by four fleshy barbels. The head is elongate and covered by large interlocking skull bones. Sturgeons are scaleless except for five rows of large, pointed, platelike scales running along the top and sides of the body. Their skeleton is part bone and part cartilage.

Sturgeons are confined to Northern Hemisphere waters. The marine species are anadromous, living as adults in marine waters but returning to freshwater rivers and streams to breed.

All species are slow-moving bottom-dwellers. Food is located by the sensitive barbels preceding the mouth and by taste buds located outside and around the mouth. Small invertebrates comprise the bulk of the diet.

The Atlantic sturgeon is distinguished by its long snout, bony plates, and tubelike mouth. This fish is caught commercially for its flesh, its eggs, which are used to make caviar, and its swim bladder, used to make isinglass.



Sturgeons are famed for their blackish roe (eggs), which are salted and called CAVIAR. The roe are usually taken by killing the female. Because female sturgeons may take up to 12 years to reach maturity, this practice has resulted in drastic reductions in sturgeon populations. The modern method of stripping (gently squeezing the abdomen to release the roe) allows the female to be returned alive to produce more eggs. Sturgeons have also been caught for their flesh and oil.

There are four recognized genera of sturgeons. *Huso* is distributed from the Adriatic Sea drainage to the Amur River in Eurasia. One species, the beluga, *H. huso*, is the largest of all freshwater fishes and at one time reached a length of 8.4 m (28 ft) and a weight of 1,260 kg (2,800 lb). It also produces the finest caviar. The genus *Acipenser* is closely related to *Huso* and is found throughout the Northern Hemisphere. Most North American sturgeons belong to *Acipenser*, including the largest North American fish, the white sturgeon, *A. transmontanus*, which reaches nearly 130 kg (286 lb). Smaller sturgeons include the genus *Pseudoscaphirhynchus* of the Aral Sea basin and the genus *Scaphirhynchus* of North America.

Sturgeon, Theodore The writer Theodore Sturgeon, b. Edward Hamilton Waldo, Staten Island, N.Y., Feb. 26, 1918, d. May 8, 1985, used the conventions of science fiction to explore serious themes. *More Than Human* (1953) is the story of seven misfits who achieve sufficiency and community through extrasensory perception. *The Dreaming Jewels* (1950; reissued as *The Synthetic Man*, 1961) explores the metaphysics of human existence, and *Venus Plus X* (1960) examines the role of sex stereotypes from the perspective of a parthenogenetic society.

Sturges, Preston [stur'-jis] For a time in the 1940s, Preston Sturges, pseudonym of Edmund P. Biden, b. Chicago, Aug. 29, 1898, d. Aug. 6, 1959, held a position of creative preeminence in Hollywood as a writer-director who was acclaimed by critics and public alike. Sturges directed his first film, *The Great McGinty*, in 1940, and followed it with a string of successes that included *The Lady Eve* (1941), *Sullivan's Travels* (1941), *The Miracle of Morgan's Creek* (1944), and *Hail the Conquering Hero* (1944), breakneck farces that shrewdly satirized American life. Sturges's touch seemed to falter, however, with the semiserious *The Great Moment* (1944), and the only time he returned to form afterward, in the black comedy *Unfaithfully Yours* (1948), the public failed to respond.

Sturm und Drang [shtoorm unt drahng] Sturm und Drang, or Storm and Stress, was a German literary and intellectual movement of the 1770s and early 1780s. Its name was derived from a play of 1776 by Friedrich Maximilian von Klinger. Its major exponents were the young GOETHE and SCHILLER, Johann Gottfried von HERDER, Gottfried August Bürger, Johann Georg Hamann, and Heinrich Leopold Wagner. In their advocacy of freedom and a return to nature, they took Shakespeare and Jean Jacques Rousseau as models. Their exaltation of the individual, personal experience, genius, and the creative imagination strongly foreshadowed ROMANTICISM.

Sturt, Charles Called the father of Australian exploration, Charles Sturt, b. Apr. 28, 1795, d. June 16, 1869, a British soldier and colonial administrator, was one of the first to venture into Australia's interior. He came to New South Wales as a British army officer in 1827 and, on an expedition west of Sydney, explored the course of the Darling River in 1828. In 1829 he charted the Murray River to its mouth. Nearly blinded through privations, he resigned from the army and settled on a grant of land; however, he lost heavily through unwise land ventures. In 1844 he made an expedition in quest of a supposed inland sea; his party penetrated more than 1,600 km (1,000 mi) northward, almost to the center of Australia, before being forced by heat and drought to return to Adelaide. Sturt was colonial treasurer (1845) and then colonial secretary (1849–51).

stuttering Stuttering is a speech disorder in which the ability to produce sentences smoothly and without conscious effort is intermittently impaired. Individual sounds and syllables may be repeated several times or prolonged beyond normal length. Some stutterers also "block" and become unable momentarily to produce any sound. These part-word repetitions, prolongations, and vocal blockages occasionally occur in normal speech, too; in stutterers, however, they occur far more often, although in certain situations, as when addressing pets, little or no stuttering occurs.

Many stutterers learn ways to prevent or minimize stuttering by timing their speech to coincide with rhythmic or sudden body movements or trying to hide their stuttering by changing words or pretending to think. In time these secondary behaviors become difficult to prevent, and some of them are accompanied by great struggle and tension.

Even without therapy, about 80% of stutterers outgrow the disorder by age 18, but the other 20% remain impaired in their ability to communicate in school, on the job, and in interpersonal relationships. No basic cause has been found. Most researchers believe that stuttering is a symptom of deficits in neurological processing that are present at birth or result from injury or illness.

Although no cause is known for certain, much is known about how the disorder develops, and effective therapies have been devised. Effective therapies result in speech that is smooth and spontaneous by dealing with both the stutterer's speech and his or her reactions to it, but many stutterers, particularly adults, must sacrifice smoothness for spontaneity and ease. Relapses to stuttering are common after many therapies; relapses can be avoided by practice outside the laboratory during therapy and by continued exercises after the completion of therapy. Children who stutter, no matter how young, should be under the supervision of a certified speech-and-language clinician.

Stuttgart [shtut'-gahrt] Stuttgart, the capital city of the state of Baden-Württemberg in the southwest corner of Germany, lies in the Neckar River valley, within 130 km (80 mi) of both the Swiss and French borders. The city covers an area of 223 km^2 (86 mi^2) and has a population of 562,658 (1989 est.).

Stuttgart and its industrial suburbs form Baden-Württemberg's most important economic center. Industrial products include machinery, motor vehicles, electrical equipment, chemicals, paper, beer, textiles, cameras, optical equipment, furniture, pianos, chocolate, and mineral water. The city is also an important railroad junction linking the Rhine Valley and southern Germany. Stuttgart, known as a publishing center, often hosts industrial and book fairs.

The old part of the city is clustered around the Old Market square, surrounded by gabled houses. From the square the city expanded into the neighboring hillsides, mainly in the 19th and 20th centuries. As a result, Stuttgart is a predominantly modern city, although many public buildings are constructed in the Renaissance, baroque, or neo-Gothic style. Stuttgart has art and music academies; a state library and opera; and a state museum, to which was added in 1984 the New State Gallery, designed by James STIRLING. It is the home of the internationally known Stuttgart Ballet.

Stuttgart's name is derived from its origins as a 10th-century stud farm (German: *Stuotgarten*) that expanded and became the property of the Württemberg family in the early 13th century. In the 14th century Stuttgart became the principal residence of the counts of Württemberg. Stuttgart became capital of Württemberg in 1482. In June 1849 it served briefly as host to what was left of the Frankfurt Parliament after its transfer from Frankfurt am Main. In September 1857 a meeting took place in Stuttgart between Emperor Alexander II of Russia and Napoleon III of France. The city center was heavily damaged in World War II, and most of its historic buildings have been rebuilt since 1945.

Stuyvesant, Peter [sty'-vuh-suhnt] Peter Stuyvesant, b. *c.*1610, d. February 1672, was the fourth and last director general of the Dutch colony NEW NETHERLAND (later New York). He began his military career at an early age and by 1632 was serving in the Dutch West India Company. Campaigning against the Portuguese in 1644 he lost a leg, replacing it with a wooden peg ornamented with silver bands. After being appointed to head New Netherland in

Peter Stuyvesant was director general of the Dutch colony of New Netherland (now called New York) from 1646 to 1664, when he was compelled to surrender the colony to the English. Although he was an efficient administrator, his religious intolerance and arbitrary methods made him an unpopular governor.

1646, he brought major political and economic reform as well as diplomatic success to the struggling colony. A dedicated and efficient yet unpopular administrator, Stuyvesant was irascible, pompous, intolerant, and authoritarian. His career came to an end when, after a surprise attack by an English naval force in September 1664, he surrendered the colony without resistance.

sty A sty, an infection of the follicle of an eyelash or of a sebaceous gland of an eyelid, is analogous to a pimple elsewhere on the skin. It is often the result of a staphylococcal infection. Sties are usually treated by a local application of antibiotics and hot or cold compresses.

Styne, Jule [styn] A British-born composer for the American stage and screen, Jule Styne, b. Dec. 31, 1905, won an Oscar (1954) for his song "Three Coins in the Fountain" and a Tony award (1968) for *Hallelujah, Baby!* Among his principal Broadway successes are *Gentlemen Prefer Blondes* (1949), *Bells Are Ringing* (1956), *Gypsy* (1959), and *Funny Girl* (1964).

Styria [stir'-ee-uh] Styria (German: Steiermark) is a mountainous, mostly forested province in southeastern Austria, bordering on Yugoslavia in the south. It covers 16,387 km^2 (6,327 mi^2) and has a population of 1,180,956 (1988 est.). GRAZ is the provincial capital. The most important economic activity is mining—iron ore in the Erzberg has been mined since before the Christian Era. Other minerals include lignite, magnesite, and graphite. Metallurgy, machinery production, and the manufacturing of paper, textiles, and leather goods are the main industries. Grain cultivation, cattle raising, and tourism complement the economy. Settled by Celts about 400 BC, the area was held by the Romans from *c.*15 BC until the 5th century. Rudolf I made Styria a hereditary Habsburg possession in 1282. In 1919 the southern part of the territory was transferred to Yugoslavia.

Styron, William [sty'-ruhn] The American novelist William Styron, b. Newport News, Va., June 11, 1924, won the Pulitzer Prize for literature in 1968 for his novel *The Confessions of Nat Turner* (1967), a fictionalized account of the American slave rebellion of 1831 as told by its leader, Nat TURNER. His highly respected first novel, *Lie Down in Darkness* (1951), is the poignant history of a deteriorating Southern family. Two later works, *The Long March* (1957) and *Set This House on Fire* (1960), present individuals struggling for their freedom against an oppressive system. *Sophie's Choice* (1979), which won the 1980 American Book Award, was made into a prize-winning film in 1982.

Styx [stiks] In Greek mythology the Styx was the river that separated HADES from the land of the living; it was crossed in a boat ferried by CHARON. Styx personified as a nymph aided Zeus in the war between the gods and the Titans. As a reward, her name became sacred.

Suárez, Francisco [swah'-rayth] Francisco Suárez, b. Granada, Spain, Jan. 5, 1548, d. Sept. 25, 1617, was the most important and influential philosopher-theologian of late SCHOLASTICISM. In 1597, he assumed the primary chair of theology at Coimbra, where he taught until retirement (1615).

Although he wrote on a variety of philosophical and theological topics, Suárez's fame rests mainly on two works: *Disputationes metaphysicae* (Metaphysical Disputations, 1597) and *De Legibus* (On Laws, 1612). The *Disputationes* presents a basically Aristotelian metaphysics, dealing with "being as such," its properties and its causes. Being is divided into God and creatures. Creatures are then divided into substance and accidents. In *De Legibus*, Suárez says that all law is rooted in the will of the lawgiver. Authority to make civil law comes from God through the people; the power of kings is limited by the grant of the people. This argument challenging the theory of the DIVINE RIGHT of kings was also made in his *Defensio fidei Catholicae* (Defense of Catholic Faith, 1613).

Suárez González, Adolfo [swah'-rayth gohn-thah'-layth] Adolfo Suárez González, b. Sept. 25, 1932, was prime minister of Spain from 1976 to 1981. He was elected to parliament in 1967 and 1971 and served (1975–76) as secretary general of the Falange party. Appointed prime minister by King Juan Carlos in 1976, Suárez speeded up democratic reform and, as leader of the Union of the Democratic Center, won (1977) the first democratic election in Spain in 41 years. As prime minister Suárez introduced many liberal measures before resigning in 1981 after criticism of his handling of the economy and regional devolution. Since 1982 he has been leader of the Democratic and Social Center party.

subatomic particle see FUNDAMENTAL PARTICLES

subduction zone see PLATE TECTONICS

sublimation (chemistry) Sublimation is the conversion of a SOLID directly into the GASEOUS STATE. The process may be expected to happen, at least to some extent, to every solid that consists of discrete molecules. For most solids the VAPOR PRESSURE is small by comparison to the prevailing pressure of the atmosphere—less than 1/1000 as great—and the sublimation will hardly be noted. Even so, the vapor of many solid substances is detectable at these levels of concentration by its odor. Other solids have an appreciable vapor pressure, and if the vapor is not contained, the solid may be converted entirely to vapor in a relatively short time (see PHASE EQUILIBRIUM). A familiar example is solid carbon dioxide, or dry ice, the vapor pressure of which becomes equal to atmospheric pressure at −78° C (−108° F). Thus, solid carbon dioxide remains at this temperature until it has sublimed completely, without melting. Liquid carbon dioxide can be obtained, but only under a pressure greater than atmospheric.

sublimation (psychology) Sublimation is the process of directing an instinctual impulse into socially acceptable channels. In PSYCHOANALYSIS it once meant desexualization, but it now has a wider meaning.

subliminal perception Subliminal perception is the purported perception of stimuli too weak to be noticed yet strong enough to influence behavior. Examples are messages flashed on a television or movie screen too briefly for a viewer to notice consciously and verbal suggestions recorded on audiocassette tapes in such a way so that they cannot be consciously heard. Whether people actually act on the suggestions remains unproven, but subliminal-perception techniques nevertheless have been widely used in advertising and on self-help audiotapes.

submarine A submarine is a self-propelled vessel capable of operating underwater. The submarines that were used in the two world wars could remain underwater for only a few hours at a time. They functioned at the surface for long periods and had to be so designed, with sharply pointed bows and long, slender hulls. In contrast, vessels designed primarily for underwater operation, such as nuclear submarines (the first true submarines), instead have a relatively broad teardrop shape or fish shape with a blunt, rounded bow and a drawn-out, tapering stern. In addition, whereas surface hulls are designed with the greatest breadth above the waterline for surface stability, underwater hulls have generally circular cross sections that increase hull strength and reduce surface area and friction drag.

A more general term also used for devices designed to operate underwater is *submersible*. Such devices range from diving bells and BATHYSPHERES to the balloonlike BATHYSCAPHES and the many small research craft available to explore the ocean depths (see OCEANOGRAPHY).

Basic Submarine Structure

A submarine is fundamentally an air space contained by a hull that is designed to withstand deep ocean pressures and to move easily underwater. The hull is a double steel shell. The inner, or pressure, hull contains all the machinery for propelling and guiding the vessel, plus living quarters for the crew. The outer hull holds the ballast tanks. When the vessel submerges, these tanks are opened and flooded with seawater. For surfacing, the seawater is forced out of the ballast tanks and replaced by compressed air.

Submersion. Flooding the ballast tanks is only one step in the process of submerging. The submarine is also propelled downward by rear-mounted propellers that force the craft forward, and by diving planes, which are movable horizontal rudders that direct the angle of the dive. When the desired depth is reached, the water level in the vessel's trim tanks is adjusted to keep the craft stable.

Power Sources. Nonnuclear submarines are propelled on the surface by diesel engines; when submerged, propulsion is provided by electric batteries and motors. The batteries must be recharged on the surface by the diesels after a short running time. Nuclear submarines are powered by a shielded nuclear reactor that generates steam to turn the propulsion turbines and also supplies electricity for subsidiary systems such as lighting, the vent controls of the ballast tanks, the operation of the torpedo tubes, the periscope, and the maintenance of the life-support systems—the air and water supply that is manufactured on board.

Nuclear power generation is self-contained: because it does not involve combustion, it does not draw oxygen from the vessel's air supply. In addition a nuclear reactor can power a submarine for many thousands of kilometers without refueling. Nuclear submarines therefore have a virtually unlimited range.

Navigation. Until after World War II, submerged submarines were navigated with a simple magnetic compass, supplemented by periscopic sextant shots and observation of the shoreline. Most periscopes could not be used at depths greater than 9 m (30 ft). Improvements in gyroscopic navigational aids ultimately led to the development of modern inertial navigation systems capable of providing accurate guidance without the need for frequent external "fixes" (see GUIDANCE AND CONTROL SYSTEMS).

The Conning Tower. The fin-shaped superstructure mounted on top of the submarine serves as a bridge when the vessel is on the surface. It holds a number of instruments: the periscopes, the various radio and radar antennas, and the snorkel, a system of air intake and exhaust pipes. On nuclear submarines the conning tower is known as the "sail" and carries a set of diving planes.

Submarine Development

The first craft known to have maneuvered underwater was constructed by Cornelis Drebbel, court engineer to James I of England, and was demonstrated on the Thames in 1620. Propelled by oars sealed at the locks by leather gaskets, it apparently submerged by admitting water into the hull and surfaced by pumping it out again.

Although the idea of the submarine continued to intrigue inventors, the lack of a power source to propel the vessel was a major obstacle to. its development. The wooden *Turtle*, designed shortly before the American Revolution by David BUSHNELL, was driven by hand- and foot-cranked propellers as was Robert FULTON's three-man metal submarine, the NAUTILUS, demonstrated for the French navy in 1801. The first successful submarine attack, some 60 years later, was made by the Confederate vessel *Hunley*.

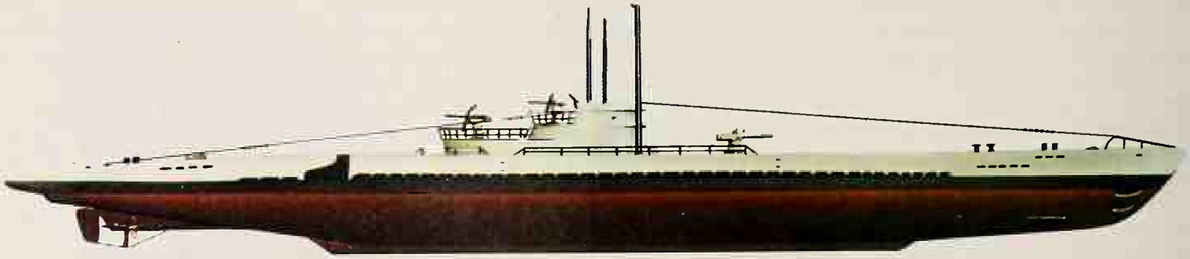
In 1900 the Irish-American John P. Holland (1840–1914) sold the U.S. Navy its first submarine. The U.S.S. *Holland* used an electric motor for propulsion underwater and a gasoline engine for surface propulsion and for recharging the batteries. The submarines of the two world wars differed in basic design from the *Holland* only in the substitution of diesels for the gasoline engine.

From the early years of the 20th century, fleets of submarines were built by every major European power. The German vessels were the most efficient; by 1911, German designers had abandoned both steam and gasoline—which was volatile, and therefore hazardous within the confines of a submarine—and had equipped all their vessels with diesel engines. Also, German periscopes were the best in the world.

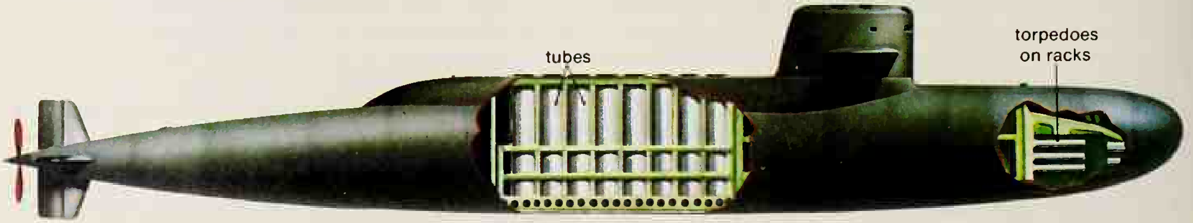
World War I provided the first opportunity to use submarines as attack vessels on a large scale. With its fleet of U-boats (*Unterseebooten*), Germany came close to severing Britain's overseas lifelines.

As in World War I, Germany began World War II with a small but seasoned submarine force and immediately applied it to isolate Britain from overseas resources. Britain countered with heavily escorted convoys, and the Germans responded by sending U-boats out in large "wolf packs" that used radio communications to search and attack in concert. Tactical complexities multiplied: hydrophones were supplemented by underwater sound-

(Above) *A Gato-class submarine was one of two classes of submarines the United States used during World War II when it standardized design. Powered by 4 diesel engines, it had a surface speed of 20.25 knots (23.3 mph) and carried 24 torpedoes and a 90-mm deck gun.*
(Below) *The German World War II U-boat was named from the German word* Unterseeboot, *meaning "submarine." These boats operated in packs by day to stalk convoys of Allied merchant ships crossing the Atlantic. At night they surfaced and attacked. They succeeded with these tactics, destroying millions of tons of Allied shipping, until the Allies used radar and air and sea escorts.*



(Below) *The U.S.S.* Patrick Henry, *a nuclear-powered submarine, carries 16 Polaris missiles that have a range of 1,920 km (1,200 mi). Polaris subs came into use during the 1960s and changed the role of the sub in naval warfare. Besides destroying enemy ships, they could launch nuclear missiles against inland targets without surfacing.*



ranging systems (SONAR) and the use of RADAR and radar warning devices became widespread. The Germans used long-range search aircraft to coordinate the wolf packs; the British and Americans replied with antisubmarine aircraft carriers and fleets of hunter-killer submarines that were guided to the German vessels by sensitive high-frequency direction-finding radios installed aboard surface vessels.

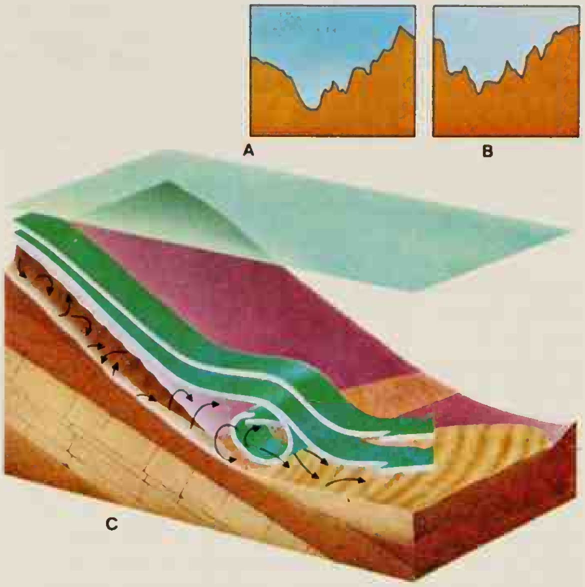
American submarines in the Pacific and British submarines in the Mediterranean enjoyed the success denied the Germans in the Atlantic. Submarine destruction of Axis supplies played a major role in the Allied victory in North Africa. American submarines effectively halted Japanese maritime commerce by mid-1944.

The Nuclear Submarine

The first nuclear submarine, the U.S.S. Nautilus, launched in 1954, resembled conventional submarines in many respects, but its great range both above and below the surface made it a revolutionary and formidable weapon. The *Nautilus* sailed almost 170,000 km (91,324 naut mi) before refueling; 146,000 km (78,885 naut mi) were spent submerged. On Aug. 3, 1958, it sailed under the Arctic ice and the North Pole.

Following the *Nautilus* and a group of submarines of the same design, the U.S. Navy developed the Skipjack class of nuclear submarine, which had a teardrop-shaped hull design and was capable of reaching underwater speeds of more than 30 knots. Succeeding types of nuclear submarines, the Thresher and Sturgeon classes, have been designed to be high-speed detection and attack vessels. The U.S.S. *Triton*, launched in 1959, is among the largest and is propelled by two nuclear reactors. In 1960 the *Triton* circumnavigated the globe underwater, traveling 78,858 km (41,500 naut mi) in 84 days.

Whereas the nuclear attack submarine represents the most advanced use of hydrodynamic technology, the nuclear ballistic missile submarine is perhaps the ultimate development of the submarine's military potential, having the ability to launch as many as several dozen intercontinental ballistic missiles while submerged. Following the first underwater launch of a Polaris missile from the U.S.S. *George Washington* in 1960, such submarines have entered the U.S. and Soviet navies in increasing numbers and are also possessed by Great Britain and France. U.S. nuclear submarine classes include those carrying the Poseidon missile and a growing new fleet of Trident submarines, which were first launched in the early 1980s.



Continental shelves and slopes along the ocean margins are cut by deep V-shaped valleys, or submarine canyons. Cross sections of the California Monterey submarine canyon (A) *and of the Colorado Grand Canyon* (B) *reveal the similarity in form and size of submarine and land canyons. Most submarine canyons are thought to have been eroded by turbidity currents* (green arrows)*—masses of dense, sediment-laden water—that flowed down the continental shelves and slopes* (C), *exploiting weaknesses in the marine substrate.*

submarine canyon Submarine canyons are deep, V-shaped valleys that lie underwater off all of the Earth's continental margins. Some canyons begin as gorges within estuaries of large rivers (for example, the Congo Canyon), and a few are in line with rivers but discontinuous with the shoreline (for example, the Indus Cone). The majority of submarine canyons begin on the continental shelf or continental slope, with no apparent relation to the drainage network on the landmass. Many of these canyons resemble the dissected terrain of a youthful land surface. This similarity suggests that submarine canyons were eroded by rivers when sea level was lower, but those canyons which are discontinuous with a shoreline or lie at great depths (some canyons lie 3,000 m/10,000 ft below sea level) could not have formed this way.

More recently, geologists have hypothesized that the majority of submarine canyons were formed by the erosive action of turbidity currents (DENSITY CURRENTS). Seawater containing sediment in turbulent suspension is especially dense. It takes the form of an erosive undercurrent rapidly moving down the slope of the continental margin. The power (and abrasiveness) of the current is greatest along the steep continental slope. As it approaches the oceanic abyssal plain, the moving front dissipates laterally into a fan shape. Turbidity currents may be triggered by earthquakes and associated landslides and by exceptional waves and tides over unstable deposits of sediment.

Certain mechanisms of the theory of PLATE TECTONICS represent the latest attempt at describing the origin of the oceanic canyons. According to this theory, when convection currents occur in the mantle beneath a continent they arch up the overlying crust and begin to tear it apart (continental rifting). Rift valleys (such as those in East Africa) form in the early stages of this process. The sides of the valleys are soon dissected by erosion, forming numerous canyons and ravines. As the continents separate completely and move off the arched zone of spreading, the continental margins subside and the canyons become drowned. The existing valleys and ravines would then act as conduits for turbidity currents.

Submarine canyons generally make excellent fishing grounds. They provide deep-water access and sediment removal channels in some harbors; and because of the phenomenon of wave refraction, the canyon heads create low-surf zones through which vessels may be safely launched.

submarine ridges see MID-OCEANIC RIDGE

subpoena [suh-pee'-nuh] A subpoena (from the Latin, *sub*, "under," and *poena*, "penalty") is a writ commanding a person either to appear before a court or magistrate and give testimony for a person named in the subpoena or to face the penalty stated therein. In addition, a subpoena duces tecum (under penalty you shall bring with you) may be issued requiring a witness who has in his or her possession documents or papers relevant to the controversy to produce them at the trial. The 6th Amendment in the Bill of Rights guarantees to a criminal defendant the right to subpoena witnesses in the defendant's favor.

subsidence Subsidence, a lowering of the land's surface, results from the settling of underlying material. Although some subsidence represents collapse of large openings—for example, sinkhole formation by collapse of cave roofs—most subsidence represents collapse or diminution of intergranular voids.

Types

Deep subsidence occurs when confined fluids such as oil, gas, or water are removed from rocks or sediments. As fluid is removed, fluid pressure drops and can no longer help support the rock against overburden pressure.

Shallow subsidence occurs where loosely packed sediments (typically mudflows) deposited in an arid environment dry out completely before being buried. A thick section of such dry deposits may accumulate, with intergranular spaces held open by the dry strength of grain-to-grain contacts and clay bonds. Subsequent downward percolation of irrigation water may cause the clay bonds to weaken, and the soil structure may collapse into a smaller volume with grains more closely packed than before.

Shallow subsidence may occur overnight; deep subsidence, however, may escape notice for years. Each type has caused local subsidence of 6 to 9 m (20 to 30 ft), and each can operate over a large area.

Hazards and Mitigation

Subsidence can disrupt structures by cracking those along the margin of the subsiding area. Even greater hazards are posed by subsidence-caused changes in the level and slope of the land surface. Lower elevation increases the possibility of flooding, particularly in low coastal areas. Slope changes prevent proper functioning of structures that depend on gentle downhill slopes, such as the irrigation canals in California's Central Valley—where deep and shallow subsidence affects an area of 13,500 km^2 (5,200 mi^2)—and the sewer lines near Galveston Bay, Tex.

Humans cause most subsidence, and they can mitigate, although not reverse, some of its effects. Deep oil-field subsidence can be halted by injecting water to maintain fluid pressure as oil is withdrawn. Deep subsidence in urban areas can be reduced by importing surface water instead of continuing to withdraw local groundwater.

substance In METAPHYSICS, substance is the unchanging, underlying reality of a thing; it is contrasted with those aspects of a thing (its accidents) which change. As used by ARISTOTLE, substance has several meanings: (1) a center that endures through changes of its properties; (2)

Passenger cars of the underground rail transit systems of 6 major cities are illustrated. The subway operated by the New York City Transit Authority (A), the second largest system in the world, has 373 km (232 mi) of track and connects Manhattan to other boroughs. This rail system serves more than 1 billion passengers annually. The U-Bahn railway of Berlin (B) has more than 900 cars in service and conveys 285 million passengers each year. Montreal's subway (C), on which the essence of a thing, or core of essential properties; (3) that which can be predicated on but never be a predicate—a logical subject; (4) that which exists irreducibly and independently; (5) that which underlies or holds together the properties of a thing, a substratum; or (6) the concrete individual, composed of both form and matter.

Later philosophers tended to use one or more of these senses from Aristotle. The British empiricists, for example, used (4) and (5), whereas the Continental rationalists emphasized (4) and G. W. F. Hegel used (3) and (4). Immanuel Kant transformed the notion of substance by equating it with "the thing in itself" (noumenon), asserting that the unity and permanence of substances are features contributed by human understanding to the world of phenomena and thus are not proper objects of knowledge.

subtraction see ARITHMETIC

subversion Subversion in politics is the action or plan of action designed to overthrow, undermine, impair, or destroy by unlawful means an existing, duly constituted government. In a democratic society that values basic rights and freedoms (see FREEDOM OF THE PRESS; FREEDOM OF SPEECH), the problem of subversion is difficult to manage. Actions that are against the safety and security of the established order, such as treason, espionage, and sabotage, are universally punishable by law. A problem arises, however, about how much freedom a democratic society should permit to individuals and groups expressing opinions and views dedicated to establishing authoritarian or totalitarian systems that would deny rights and freedoms to views other than their own. Some say that if freedom is denied to dissident ideas that challenge the dominant consensus in a democracy, all criticism may then be in danger of being suppressed. Others fear, however, that without certain restrictions on freedom of expression and association, conspiratorial movements dangerous to a free society cannot be controlled. In the United States the Supreme Court has made a distinction between acts or words promoting actual subversion and the teaching of revolutionary beliefs, although it has difficulty in deciding where to draw the line between the two. In 1950, Congress passed the McCARRAN ACT, which established the Subversive Activities Control Board to identify subversive groups. The board was abolished in 1973.

See also: SEDITION; SMITH ACT; UN-AMERICAN ACTIVITIES, HOUSE COMMITTEE ON.

subway A subway is an underground municipal railroad that provides rapid transit for large numbers of people between city centers and outlying districts. Each train consists of from two to ten electrically propelled cars; electricity is usually taken from a third rail mounted parallel to the running rails.

Rapid-Transit Systems

Most subways are parts of rapid-transit systems that include ELEVATED RAILROADS and surface-level trackage. Surface running is often used in outlying parts of a rapid-transit system to reduce construction costs. Terrain and geographical conditions also determine the type of system built. Where the water table is close to the surface, as in Miami, Fla., building a subway is difficult and costly; in such places a predominantly elevated rapid-transit system may be built.

Subway Construction

Of the several means used to construct subways, many are also used in other kinds of tunneling and are discussed under TUNNEL. In the most common method, called cut-and-cover, the street is excavated from the top, and water and gas mains, sewers, and other obstructions are moved. The steel-and-concrete work is put in place, and the street is replaced over the tunnel roof.

Less disruptive of street use is the so-called Milan method, first used in that Italian city. Deep trenches for the

construction began in 1962, features rubber-tired cars to provide an exceptionally smooth, quiet ride. London's subway (D), the most extensive system in the world, was opened in 1863 and has 9 separate lines. Stockholm's subway (E) uses only motor and trailer cars built in Sweden. The system carries 175 million passengers annually. The Paris Métro (F), which began operating in 1900, is notable for the large number of stations (404) along the length of the system.

tunnel walls are excavated along the subway route, and the concrete for the walls is poured. The street surface is then removed, and excavation is made down to the level of the tunnel roof, which is poured and attached to the walls; the street is then quickly replaced. Later, the earth inside the roof and walls is excavated through the ends of the tunnel.

Shaft tunneling is the least disruptive but most costly means of subway construction. Vertical shafts are dug, usually at several locations along the subway route, and then horizontal tunnels are driven away from the shafts.

Subway Development

In the middle of the 19th century, because of the congestion in major cities, a separate artery of high-capacity, rapid passenger transportation began to be developed. Because London had sufficient capital, its Metropolitan Railway was the first (1863) to go underground. London's first subways were steam operated, which caused significant operating problems because of the smoke. At the end of the 19th century, with the development of railways run by electricity, subway systems in London, Paris, and Berlin were expanded. Boston built the first U.S. subway in 1897, initially with streetcars instead of trains. New York City opened its first permanent subway in 1904 and for the next 40 years continued to enlarge its subway-system mileage by both extending its underground trackage and replacing its elevated railroads with subways. Philadelphia opened its first subway in 1907; Moscow, in 1935; Chicago, in the early 1940s. The initial era of U.S. subway construction and expansion covered the years 1900 to 1930. After 1930 the expense of construction, economic depression, and loss of mass-transit patronage to the automobile hindered new subway construction for many years.

Soon after World War II, subway construction resumed at a rapid pace in all parts of the world except the United States. Since 1945 almost every major capital in the world has built a subway rapid-transit system in order to exploit the substantial advantages in fuel efficiency, speed, and alleviation of congestion. Notable examples include the Mexico City subway, the Montreal subway, and, recently, the Hong Kong subway.

Since 1960 in the United States subway systems have been constructed or are under construction in the San Francisco area; Washington, D.C.; Baltimore, Md.; and Atlanta, Ga. The 121-km (75-mi) BART system in San Francisco was a particularly ambitious project. Construction began in the 1960s, and the first segments were opened in 1972. BART was intended to usher in a new era in rapid transit, with computer-controlled trains and stations designed to be architectural masterpieces. It was well into the 1980s, however, before BART achieved its full ridership capacity—over 200,000 passengers daily.

In terms of mass-transit needs, recent U.S. subway development has been inadequate. The rising price of fuel in the 1970s increased the cost advantage of subways over automobiles, but a shortage of mass-transit funds, particularly in older systems, has led to a spiral of rising fares, deteriorating conditions, and decreased ridership. In addition, the high cost of building subways makes it likely that other types of mass transit, such as elevated railroads, will be built instead.

succubus see INCUBUS

sucker Sucker (family Catostomidae) is the common name for any of more than 100 species of fishes that closely resemble minnows in fin arrangement. They are found most commonly in North America but also occur in Siberia and China. Some suckers are lake species, nocturnal and schooling. Others are solitary and live in riffle areas of swift rivers. The mouth is underneath and can be protruding, hence the name sucker. They are bottom-feeders, usually eating small crustaceans and larval insects. The males develop hard protuberances during spawning season. Suckers may live more than 10 years.

Suckling, Sir John Sir John Suckling, b. Whitton, Middlesex, February 1609, d. 1642, one of England's CAVALIER POETS, studied at Cambridge and became a prominent supporter of King Charles I. His plays include *Aglaura* (1637), with two final acts, one comic and one tragic, and *The Goblins* (1638). A wealthy man, Suckling was celebrated in his own time for his gallantry and extravagance but is now remembered for his lyric poems and the witty mock-pastoral "Ballad upon a Wedding."

Sucre [soo'-kray] Sucre, the legal and judicial capital of Bolivia (La Paz is the administrative capital), is located in the southern part of the country at an elevation of 2,790 m (9,154 ft). The commercial and agricultural center of the surrounding region, it has a population of 86,609 (1985 est.). An oil refinery and a cement plant are located there. Long isolated from the rest of Bolivia, Sucre has retained much of its colonial heritage. Public buildings include the legislative palace, where the declaration of independence was signed in 1825; the palace of justice, the seat of Bolivia's judiciary; the modern palace of government; and a 17th-century cathedral. St. Francis Xavier University was established in 1624.

The city was founded by Spaniards in 1538 and was known during the colonial period as Chuquisaca. In 1809 it became the center of the movement to overthrow the Spanish colonial regime. Its name was changed to Sucre in 1840 in honor of Gen. Antonio José de Sucre.

Sucre, Antonio José de Antonio José de Sucre, b. Feb. 3, 1795, d. June 4, 1830, a leader of South America's independence movement and Simón BOLÍVAR's most able commander, became Bolivia's first president (1826–28).

Joining the struggle against Spain in 1811, Sucre fought in the abortive campaigns of Francisco de Miranda (1812) and Antonio Mariño (1813). He negotiated (1820) an armistice with the Spanish, proving his skill as a diplomat. His brilliant victory (1822) at Pichincha liberated much of present-day Ecuador, and his strategy assured South American independence in 1824 at Ayacucho, the final and most important battle of the war.

Bolívar, who left the Andean area soon after independence was achieved, was instrumental in Sucre's election (1826) as the first president of the new republic by a constituent assembly in Upper Peru (present-day Bolivia). Sucre effectively organized the government and economy, but he resigned in 1828 and returned north to the new state of Gran Colombia. He then defended Ecuador from a Peruvian invasion in 1828–29 and was subsequently asked to act as president of a congress formed to ensure Colombian unity. The project failed, and Sucre was assassinated while returning home to Quito.

Sudan [soo-dan'] Sudan is the largest country in Africa. Located in the northeastern part of the continent, it is bordered on the north by Egypt, on the east by the Red Sea and Ethiopia, on the south by Kenya, Uganda, and Zaire, and on the west by the Central African Republic, Chad, and Libya. It is mainly an agricultural nation. Long under joint British-Egyptian rule, Sudan became independent on Jan. 1, 1956. Khartoum is the capital.

Land and Resources

Away from the Nile River most of the Sudan is a vast arid or semiarid plain that rises gradually to the east, south, and west. The extensive Kordufan Plateau, in central Sudan, has elevations of about 600–900 m (2,000–3,000 ft). Elevations exceeding 3,000 m (10,000 ft) are found in the Jebel Marra in the west and near the Ugandan border in the south, where the country's highest mountain, Kinyeti (3,187 m/10,456 ft), is located. Some lower elevations occur along the eastern rim, in the Ethiopian Highlands, and also bordering the Red Sea.

The desert region north of Khartoum has less than 100 mm (4 in) in annual precipitation and summer daytime temperatures that often reach 40° C (104° F). The Red Sea coast has lower temperatures and slightly more precipitation, which falls mostly in the winter. The southwestern part of the country is hot and humid, with average temperatures of about 26° C (79° F) all year round and rainfall of more than 1,000 mm (40 in).

Drainage is provided by the two branches of the Nile River. The White Nile enters the Sudan from Uganda in the south and is joined by the Blue Nile at Khartoum. The Blue Nile contributes most of the floodwater; much of the White Nile flow is lost in the swampy regions of the southern Sudd area. The 354-km-long (220-mi) Jonglei Canal, begun in 1980, was designed to divert the flow of the White Nile around the Sudd and provide irrigation water for northern Sudan and Egypt, but civil war has halted work on the project.

Natural vegetation consists of swampy grasslands in the south, tropical rain forests in the southern uplands,

AT A GLANCE

REPUBLIC OF THE SUDAN

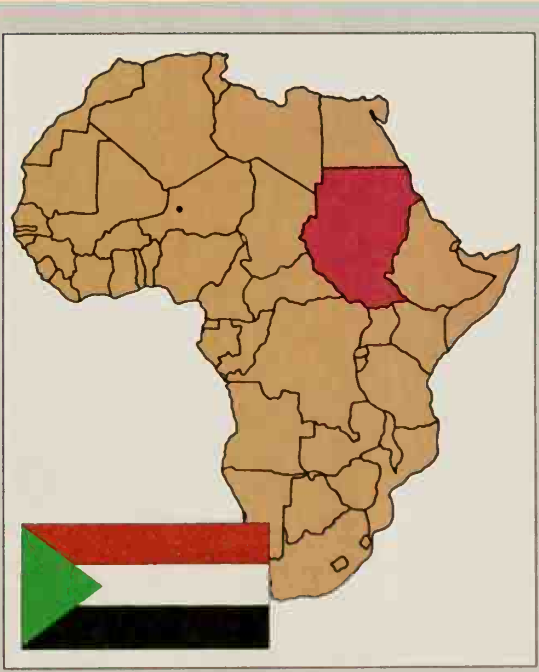
Land: Area: 2,505,065 km^2 (967,244 mi^2). Capital: Khartoum (1983 pop., 476,211). Largest city: Omdurman (1983 pop., 526,287).

People: Population (1990 est.): 24,971,806. Density: 10.0 persons per km^2 (25.8 per mi^2). Distribution (1985): 29% urban, 71% rural. Official language: Arabic. Major religions: Sunni Islam, traditional religions, Christianity.

Government: Type: military rule. Legislature: none. Political subdivisions: 9 states.

Economy: GNP (1988): $10.09 billion; $420 per capita. Labor distribution (1987): agriculture—69%; industry, mining, and construction—8%; services, trade, and government—23%. Foreign trade (1989 est.): imports—$1.2 billion; exports—$550 million. Currency: 1 Sudanese pound = 100 piastres.

Education and Health: Literacy (1991): 25% of adult population. Universities (1984): 5. Hospital beds (1981): 17,205. Physicians (1981): 2,122. Life expectancy (1990): women—55; men—51. Infant mortality (1990): 107 per 1,000 live births.

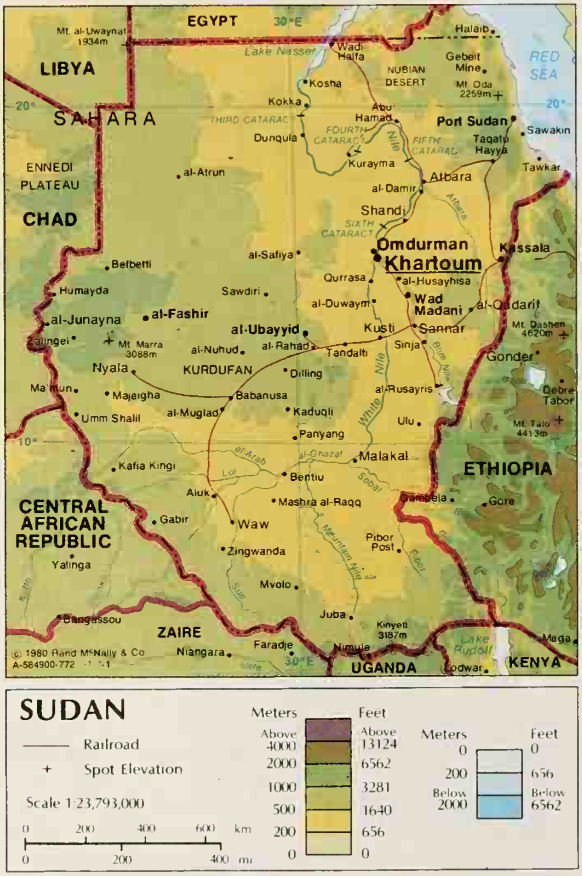


savannas in the southeast, and semiarid to arid conditions in the north. Animal life includes elephants, rhinoceroses, lions, leopards, zebras, giraffes, crocodiles, hippopotamuses, monkeys, antelope, gazelles, and rabbits.

The principal resources of the Sudan are agricultural. Inadequate transportation has restricted the development of the country's modest reserves of iron ore, copper, manganese ore, chromite, and gypsum. Some petroleum has been found off the Red Sea coast. Gold is extracted in small quantities.

People

The Sudan is divided ethnically into two major regional groupings. In the 12 northern provinces, which cover two-thirds of the land area and include a majority of the urban centers, most of the inhabitants are Arabic speaking and adhere to Sunni Islam. The southern region is inhabited by various Nilote ethnic groups who speak African languages and are mostly animists, although there are some Christians among them. Besides Arabic—the official language—and the African tongues, English is a principal language of the southern region. Political disputes and cultural differences between the north and the south have long threatened national unity.



Most cities are rather small. Other than the urban clusters of Khartoum, Khartoum North, and OMDURMAN, the largest centers are Port Sudan on the Red Sea and al-Ubayyid in the Kordufan. On the whole, the country is sparsely populated. The Nile Valley is the most densely inhabited; the northwestern deserts are practically empty.

The literacy rate is low. Primary schools, maintained by the government, use Arabic for instruction. Khartoum University (1956) and the Khartoum branch of Cairo University (1955) offer instruction in the English language. The Islamic University (1965), in Omdurman, uses Arabic.

Economic Activity

Although 37% of the Sudan is arable, only 5% is under cultivation. More than half of the people engaged in farming are subsistence farmers. Crops grown include cotton, grain sorghum (durra), dukhn (pearl millet), sesame, peanuts, wheat, maize (corn), dates, and oilseeds. Camels and sheep are exported. Cotton, grown mainly in the Gezira region between the Blue and the White Nile, is the chief cash crop, although it now provides only 30% of export revenues. Sudan supplies most of the world's gum arabic. Manufactures include cement, textiles, pharmaceutical supplies, shoes, and processed foods.

Sudan has long been considered the potential breadbasket of Africa, but development has been hindered by inefficient management, deteriorating equipment, and an inadequate and costly transportation system. Since 1983 the economy—particularly the agricultural south—has been devastated by famine and a civil war in which both sides have used food as a weapon. (About 500,000 civilian deaths were attributed to war and famine from 1986 to 1989.)

Government

The constitution of 1973 was suspended following a 1985 coup, and the country was renamed Republic of the Sudan. In May 1986, under an interim constitution, the ruling military council transferred power to a civilian government headed by a prime minister responsible to an elected National Assembly. After a 1989 military coup, a new revolutionary council suspended the constitution and declared a state of emergency.

History

Egypt first unified the small, independent Sudanese states, some of which had existed since the early Christian era, in 1820–21. Later in that century, the Muslim MAHDI ("messiah") Muhammad Ahmed led a religious revolt. He captured El Obeid in 1883 and Khartoum in 1885 after a long siege in which the British general Charles George GORDON was killed. The Mahdi died the same year, and the Mahdist state was overthrown by British-Egyptian forces led by Lord KITCHENER in 1898. Sudan then came under the joint rule of Britain and Egypt. Independence was achieved on Jan. 1, 1956, but the governments during the first 13 years of independence—both civilian and military—were unstable. A

The White Nile originates in the lakes of the East African Rift Valley and joins the Blue Nile north of Khartoum. Both streams are dammed near their confluence to control flooding and provide water year-round for irrigation.

coup on May 25, 1969, finally gave power to Gen. Gaafar al-NIMEIRY.

Siding with the Arabs, Sudan declared war on Israel on June 6, 1967, broke relations with the United States, and was forced to rely heavily on Soviet assistance for several years. A briefly successful Communist coup occurred in July 1971. After Nimeiry regained power, he turned again to the United States for aid. A 17-year-long civil war between the Christian and animist south and the Arab north ended in 1972 with a peace agreement granting the south a regional government and autonomy on most regional matters.

Nimeiry, one of the few Arab leaders to support the 1979 Egyptian-Israeli peace treaty, survived numerous coup attempts and was reelected president in 1977 and 1983. In the latter year, however, civil war again erupted when he divided the southern region into three provinces and imposed strict Islamic law throughout the country. Nimeiry's increasingly erratic policies eventually provoked opposition among almost every segment of Sudanese society. He was overthrown in a military coup on Apr. 16, 1985. After the first multiparty elections since 1968, held in April 1986, a coalition civilian government headed by Prime Minister Sadeq al-Mahdi assumed power. Mahdi failed to end the rebellion in the south and was overthrown on June 30, 1989, in a fundamentalist-inspired military coup led by Gen. Omar Hassan Ahmed Bashir. Bashir reimposed Islamic law and signed (March 1990) a declaration of integration with Libya.

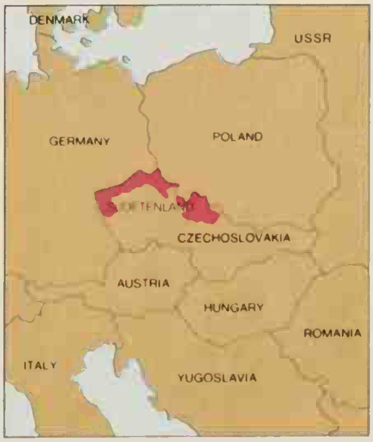
The anti-Western government, pro-Iraq during the 1991 GULF WAR, became increasingly isolated diplomatically, hampering international efforts to help millions of people in both the north and south facing famine. The country was divided into nine states in 1991 in an effort to end the war; much of the south was under de facto rebel control.

Sudbury [suhd'-bur-ee] Sudbury (1986 pop., 88,717) is a Canadian city in southeastern Ontario about 65 km (40 mi) north of Georgian Bay of Lake Huron. Mining has traditionally been the base of the economy, although its significance has declined in recent decades. The area is the world's largest single source of nickel, and its copper and platinum mines and lumber mills are also of importance. Laurentian University (1960) is located in the city.

During the construction of the Canadian Pacific Railway in 1883, copper and nickel deposits were discovered in the area. The city became one of the world's richest mining centers.

Sudeten Mountains [zoo-day'-ten] The densely forested Sudeten Mountains (or Sudetes) extend about 300 km (185 mi) along the Czechoslovak-Polish border. The highest peak is Sněžka (1,602 m/5,256 ft) in the Krknoše range. Mining, lumber, glass, and textiles form the base of the regional economy, and the main crops are oats and potatoes. Since World War II, tourism has also been important, especially for winter sports. The major cities are Liberec, Jablonec, and Nisou, all in Czechoslovakia.

Sudetenland [zoo-day'-ten-lahnt] The Sudetenland (a 20th-century term) is a geographical region in northern Czechoslovakia, inhabited until 1946 by Germans. It comprises portions of the Sudeten Mountains. The original German settlers arrived there in the 12th and 13th centuries, but the region was traditionally part of Bohemia. In 1938 the Sudetenland was annexed by the German Third Reich (see MUNICH CONFERENCE), but it was restored to Czechoslovakia in 1945. Most of its German-speaking population of 3 million was then transferred to Germany.



The shaded portion of the map indicates the Sudetenland, a mountainous region in Czechoslovakia traditionally inhabited by German-speaking peoples. Under the pretext of protecting the Sudeten Germans, Germany annexed the region in 1938, in spite of the fact that the Sudetenland had been accorded full autonomy by the Czech government only a year earlier.

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